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Contents.

	PAGE
Apprenticeship Courses	43
British Industries Fair, 1923	43
An Apprenticeship Course in Foundry Practice.—I.	44
The Development and Manufacture of High Tenacity Brass and Bronze	47
British Iron Ore Resources	49
American Methods of Manufacture of Malleable Iron Castings and Some Data in Connection with the Finished Product	50
Publications Received	53
Book Review	53
The Training of Foundrymen	54
Correspondence	58
American *versus* British Grey Cast Iron	59
Display Facilities for British Travellers in New York	63
Contracts Open	63
Trade Talk	64
Company News	64
Gazette	64
Iron and Steel Markets	66

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Apprenticeship Courses.

In this week's issue, we commence a special series of articles designed to form a course of instruction suitable for all grades of foundry apprentices. Additionally, a Paper by Mr. Liardet, given before the West Ridings of Yorkshire Branch of the Institution of British Foundrymen, on a system of education of such youths is also given. This particular system has been evolved by an industrialist and not by an educationalist, and has much to commend it. It includes evening classes, and if any boy wishes to make progress he must be made to realise that nothing is gained without hard work. No person will make substantial progress working only from eight in the morning to five at night. If classes are given during the day involving a minimum of sacrifice on the part of the apprentice, then the appreciation of the apprentice varies directly with that sacrifice. In plain words, if things are made too easy facilities are not appreciated. We would point out that there are a considerable number of world-renowned metallurgists who have received the whole of their theoretical training at evening classes. We do not want to moralise, but managers might well point out to apprentices that there is plenty of room at the top of the tree; it is only the bottom which is crowded. We are minded to say this, as some pertinent remarks on the subject were made by Mr. Wilkinson, of Birmingham, who rightly emphasised the importance of sympathetic interest on the part of the foundry manager. Boys in foundries are not usually there by choice, but by force of circumstances, because conditions in the past have not been such as to attract the best type of lad.

Now, nearly all boys glory in two things: practical chemistry and furnace work; and we suggest that these two subjects should be tackled very early in his apprenticeship. We notice Mr. Liardet's scheme provided chemistry very early on. That is certainly very desirable, and it should be followed immediately by the practical participation in melting processes. The students will learn more about metallurgical calculations and processes on a furnace charging-platform in an hour or two than in several lectures. Owing to the absence of restriction, any boy not being quite clear gets his information in his own way, either by direct application to the demonstrator or to another student.

The object of the installation of plant and laboratories in technical colleges is not to give practical instruction. That can only be gained in the works; but they help to bring the student and lecturer into closer association and to make the lectures much more interesting and intelligible.

Now, the instruction which will be given in the series of articles has not for its object the replacing of instruction given in technical classes. It will be auxiliary and helpful alike to instructor and teacher. Mr. Gallon pointed out, when discussing Mr. Varlet's Paper at Birmingham, that very few foundry boys can visualise a drawing. Such instruction cannot be included in the series of articles now commencing. The main object of these articles is to interest the lads in their work by supplementing the practical information they obtain in the foundry or pattern shop and the evening classes.

British Industries Fair, 1923.

We have received from British Industries Fair (Birmingham) Incorporated a copy of the prospectus of the Fair to be held in Birmingham from February 19 to March 2, 1923.

The Fair, which is only open to exhibits made by British manufacturers and to British wholesale firms taking the whole output of a British factory or holding the sole selling rights of patented or proprietary articles manufactured in the British Empire, is divided into eleven groups, including brassfoundry, hardware, and ironmongery, all descriptions of ferrous and non-ferrous metals and alloys. General machinery, machine tools, engineering and industrial tools; sheet-metal machinery, etc., etc. Foundry appliances and requisites; malleable ironfoundry, drop forgings, die castings; general castings; wire, tube, and rolling-mill plant; hydraulic plant; scales, balances, and other weighing instruments; measuring and testing instruments and appliances; heat treatment of metals, etc.

The Secretary is Mr. G. Henry Wright, F.C.I.S., and the registered office is at the Chamber of Commerce, 95 New Street, Birmingham.

An Apprenticeship Course in Foundry Practice.—I.

By Ben Shaw and James Edgar.

PATTERN-MAKING MATERIALS.

It may be as well to make it quite clear in the opening sentence that these articles are intended for young journeymen and apprentices—especially for apprentices. The writers have been impressed in the course of their experience with the lack of knowledge among their fellow craftsmen of the materials used by them, and also of the principles of the various operations employed. The endeavour will be to discuss the properties of materials and describe methods of construction in a simple, lucid fashion, and any piece of work—generally of a simple kind—that is described will be used simply as the instrument of convenience which for the purpose may be more effective in conveying what is meant than a description in abstract.

In discussing the proportion of pattern-making materials we begin at the very genesis of foundry work. The resultant castings depends to a considerable extent on the quality of the pattern, and this in turn depends on the quality of the material used.

The Chief Material.

Timber is the most important pattern-making material, and yellow pine for all but small work or medium-sized work from which it is contemplated that a quantity of castings will be required, is almost universally used. It is a mellow, comparatively straight-grained wood, fairly free from knots and shakes, and easily carved. It does not warp or absorb moisture to anything like the extent of the open-grained spruce, which should never be used for pattern-making. Spanish mahogany makes good small patterns, but it is seldom used, quite a good substitute being found in American baywood or Honduras mahogany. Teak is used in some pattern-shops, and it has some outstanding qualities. It does not warp much, and the natural oil it contains assists in preventing the absorption of moisture; it is, therefore, not liable to shrink or swell, but, on the other hand, it is rather brittle, and edged tools require very frequent attention when working it. Cypress and red pine are used as small quantities, as also are sycamore, maple, plane tree, lime tree and cherry. Sycamore, maple, or plane tree are tougher and more pliable than mahogany, and they are sometimes given preference for small or standard work on that account. Both lime and cherry are particularly useful when much carving is to be done, very fine edges standing considerable wear without damage. Though these woods are used to a limited extent, they invariably take more time to work than baywood. Lignum vitæ is not actually used for making patterns, but pattern-makers often bush stern-tubes in marine shops, for which purpose this hard timber is always used because of its self-lubricating properties.

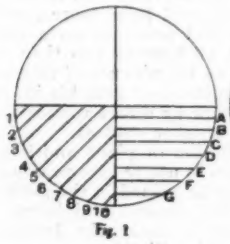


Fig. 1

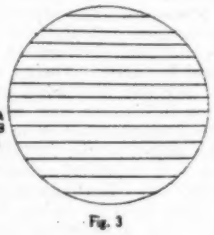


Fig. 3

Hard and Soft Timber.

A great deal of research work has been carried out in order to find satisfactory wood preservatives for construction work, but the pattern-maker is not much concerned about that; patterns are preserved by the methods adopted in constructing them, and also by the paint or varnish used in coating them. The question of hardness is an interesting one. It is rather difficult to get out a table showing comparative hardness of various woods, but the following is sufficiently accurate for practical purposes. Some of the woods are never used by the pattern-maker and others but seldom, but a comprehensive knowledge of the subject is of value:—

Very soft—Linden, poplar, willow.
Soft—Pine, fir, larch, alder, horse chestnut.
Somewhat hard—Beech, oak, walnut, pear, apple, chestnut.
Fairly hard—Ash, plane, plum, elm.
Hard—Maple, yolk-elm, wild cherry, sycamore, yew.
Very hard—Almond, hawthorn.
Hard as bone—Lilac.
Harder than bone—Lignum vitæ.
Hardest—Ebony, which is as hard as stone and very tough.

Specific Qualities of Various Woods.

Spruce or white fir, as it is frequently called, grows in North America and Norway chiefly. It is at its best when about 80 years old. Many species of spruce trees are found in our public parks. Neither of the two varieties which are known as American or Baltic spruce, is durable. Red Pine is another American variety which is more used by joiners than pattern-makers because it is much stronger than yellow pine. Yellow pine is imported chiefly from America. The tree grows to a great height and logs 70 ft. long and 24 in. wide are easily obtained. It has been described as the finest, softest, and most easily worked timber obtainable, and this is not an exaggeration. It contains very little resin, and its texture is very even, which renders it particularly suitable for patterns. It is graded according to quality, like most other timbers, and although the best quality is not always used for pattern-making, it ought to be for high-class work. Pitch pine is not suitable for pattern-making at all, as it so readily absorbs moisture. A pitch-pine pattern tears the sand and necessitates a great deal of patching by the moulder after the pattern has been withdrawn from the mould. The ridged surface which results after a pitch-pine pattern has been used a few times is because of the hard and soft annular rings. The soft light rings shrink, while the hard or dark rings retain their shape, or the soft rings absorb more moisture which causes them to swell beyond the hard grain. Much need not be said about true mahogany, by which reference is made to that which is imported from the West Indies, because very little of it is used. At different times over 60 varieties of timber have been sold as mahogany, Baywood, which is the "mahogany" most used in pattern-shops, grows about the Bay of Honduras in Central America. It is in every way a satisfactory timber. It takes glue as well as yellow pine, has a very even grain with little difference in texture, and it works well. It is straight-grained, and not liable to warp or twist, and if it has been well seasoned it is durable. With regard to the grading of timber no standard is possible, and a timber merchant's grading is not always a bona-fide indication of good or bad quality.

Timber Merchants' Terms.

In the pattern-shop all the timber is in the form of boards or planks, but it is not always bought in this form. It is as well for pattern-makers to know the technical terms used by timber merchants for timber of different sizes. Board is the name given to any kind of wood of whatever length and width that does not exceed 2 in. in thickness, while a deal is 9 in. wide and not more than 4 in. thick, and a batten is 7 in. broad and not over 4 in. thick. Quartering is the term used for narrower material not over 4½ inches wide or thick, whilst a plank is 11 in. or more wide and from 2 in. to 6 in. thick. Yellow pine is usually sold by the Petrograd standard, which is 165 cub. ft. or 720 planks 11 in. by 3 in. and 12 ft. long. The hard woods are usually sold by the foot run or by the superficial foot, which means 12 in. by 12 in. by 1 in., while exceptional woods, such as Lignum vitæ, are frequently sold by weight. The trunk of a tree with all

its branches removed is called a log, and after it is roughly squared it is known as a baulk. If a log is sawn up the centre the parts are called flitches, and this term is also applied if it is sawn in parts over 6 in. thick. It may be pointed out the quarter sawing is not synonomous with quartering, but is given to the method of sawing a log into four quadrants, as indicated by the lines in Fig. 1. Each quarter is then sawn into boards, as indicated by the lines 1, 2, 3, etc. This is a wasteful method, and is not very often employed. Fig. 2 is chiefly of interest to pattern-makers as showing the scientific cutting as adopted by some timber companies to prevent waste, and at the same time obtain a suitable grain for varying purposes.

The conversion of timber is done in many ways; Fig. 3 is the most economical method, but not the most satisfactory. The centre or heard board does not warp, but the thickness at the centre and edges will vary. The other boards will warp as shown, and the reason for the warping will be made clear later on. The method of quarter-saving and the ripping into boards is indicated by the lines E, F, H, etc. Fig. 1 gives better boards. Young trees have sometimes got a wandering heart, and boards cut from them will twist badly.

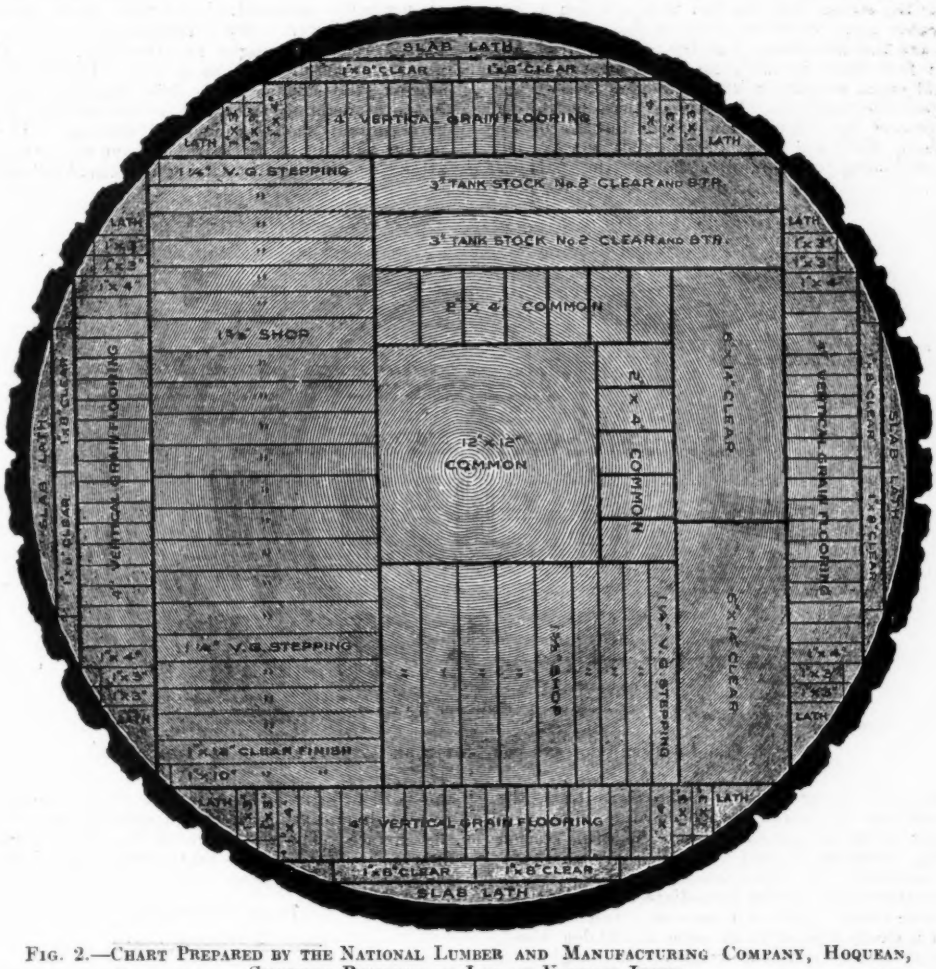


FIG. 2.—CHART PREPARED BY THE NATIONAL LUMBER AND MANUFACTURING COMPANY, HOQUEAN, SHOWING POSITION IN LOG OF VARIOUS ITEMS.

Important Definitions.

There are certain definitions apart from those used by timber merchants to describe different-sized boards which ought to be known to every pattern-maker, those that have to do with the trees' growth. What is the cause of shrinking, swelling and warping? If the end of a sawn log is examined, a number of rings more or less concentric with the outside of the log will be found, and these indicate approximately the age of the tree. These rings are called annular rings. There are radial lines resembling cracks, and these are usually called silver or medullary rays. Now, if a cross section of timber, say yellow pine, is examined under a microscope, or, better still, microphotographed, it would be found that there are innumerable cells, and that the cells which represent the summer growth of the trees are much larger and more open than those that represent the winter growth. The defining line is quite easily distinguishable. The cells are filled with water, and the process of eliminating it is called seasoning. As the wood dries, the cell walls shrivel and the width of the timber becomes less. In length, however, there is no perceptible shrinkage. Timber cracks are nearly always radial or parallel with the medullary rays. Heart wood does not warp like outside timber. Timber cut in winter is superior because there is less sapwood, and an old tree has less sapwood than a young tree. It may be admitted that, however much a man may know of the theory of timber craft, practical experience is very valuable. An old hand will wet timber with his tongue, and watch it absorb the moisture; he may judge by smell, he may try its weight, and he will invariably inspect the end grain carefully.

Certain experiments may be tried from which much useful knowledge will be gained. One method, recommended by a timber expert, is to take two pieces of timber of equal size, one from the centre and the other from the side of the board. soak them in water for a few hours, and then dry them again. If the outside contains sap it will be much longer in drying.

Seasoning.

A great deal has been written on the seasoning of timber, and new processes are continually being discovered. Dry timber does not exist. Perfect dryness is a condition in which all moisture has been evaporated, leaving dry fibre and a minute amount of granular residue from the sap. The moisture content is always tested before the wood is placed in the kiln, in order that the time neces-

sary can be accurately calculated, and delicate scientific instruments are used for the purpose. The pattern-shop partially seasons its own timber by stacking it for a time in the open air or placing it in a drying shed. Very few pattern shops have a drying room, but there are some, and the drying is done too rapidly, with the result that when it is taken out and sent into the foundry, especially if unpainted, it immediately absorbs moisture and swells. The air seasoning of wood is an old practice. No really systematic attempt has ever been made (as far as the authors can ascertain) to work out the exact conditions to produce the best results. It is too often forgotten by pattern-makers that timber is stacked or racked to season it. We hope to discuss this at greater length in a subsequent article, but the pattern-maker ought to know something of the kiln-drying process which takes place before the timber reaches him. The U.S. Forest Products Laboratory, which has done more research work than probably any other body on either side of the Atlantic, states that the two things which a kiln operator must be able to prove at the end of a kiln run are that his timber is as dry as is required, and it is free from invisible seasoning stresses which would cause warping when the wood is re-sawn and shaped into patterns. Neither of these points can be proved by examination of the outside of the timber. They are easily determined, however, by the following tests, and although the pattern-maker may never have to make these tests, the information is invaluable as showing what does happen given certain conditions. The full section A, Fig. 4, should be used to find the average moisture content of the dried stock. To do this, weigh on a balance the section immediately after cutting accurate to one-tenth of 1 per cent., and then dry it on a steam pipe or in an oven at 100 deg. Cent. until it reaches constant weight. The weight lost during this drying is the weight of the moisture by the weight of the oven-dried section, and multiply by 100. This will give the percentage of moisture in the section, and also in the stock in that part of the kiln from which the sample was taken. For pattern-making, the moisture content of any board in the kiln should not vary by more than 2 or 3 per cent. from the final moisture content specified.

Section B should be used to find out whether the stock is uniformly dry from centre to outside. In order to do this the section must be cut apart and the moisture content of the inside and outside found separately. If the stock is 1½ in. or more in thickness, cut the section parallel to its edges to get an outer shell of material ¼ inch thick. If the stock is less than 1½ in. thick, cut section B so as to get an outer shell and inner core each one-fifth the total thickness of the section. Find the moisture content of each piece by the method used for finding the moisture content of section A. The moisture content of the inside and outside of the stock should be equalised by steaming, if necessary, to within 2 per cent. before the timber leaves the kiln.

The third and fourth sections, C and D, are for case-hardening and moisture distribution tests. Saw section C parallel to the wide faces of the original board to form tongues or prongs, leaving about ½ in. of solid wood at one end of the section. If the stock is less than 2 in. thick make two saw-cuts; if it is more than 2 in. thick make five saw-cuts. From sections having six prongs break out the second prong from each side, leaving two outer and two central prongs. From sections having only three prongs remove the centre prong. In section saw one central saw kerf to form two prongs. Stand the section on end in some convenient place in the shop to dry. The action of the prongs from the moment of sawing should be observed carefully. Do they bow in or out or remain straight on the saw? Do they change shape after room-drying? If the prongs remain straight both on the saw and after room-drying the timber is perfectly seasoned, being free from stresses and uniformly dry throughout. If the prongs remain straight on the saw, but turn in after room-drying, the moisture distribution is uneven, the surface being drier than the inside. A short steaming treatment to balance the moisture content should relieve all stresses. If the prongs turn in on the saw, and do not turn out after room-drying, the timber is "case-hardened" and is drier outside than inside. Use a steaming or high humidity treatment to moisten and soften the surface. The shrinkage of the outside in re-drying should relieve the interior tension and cause the stresses to disappear.

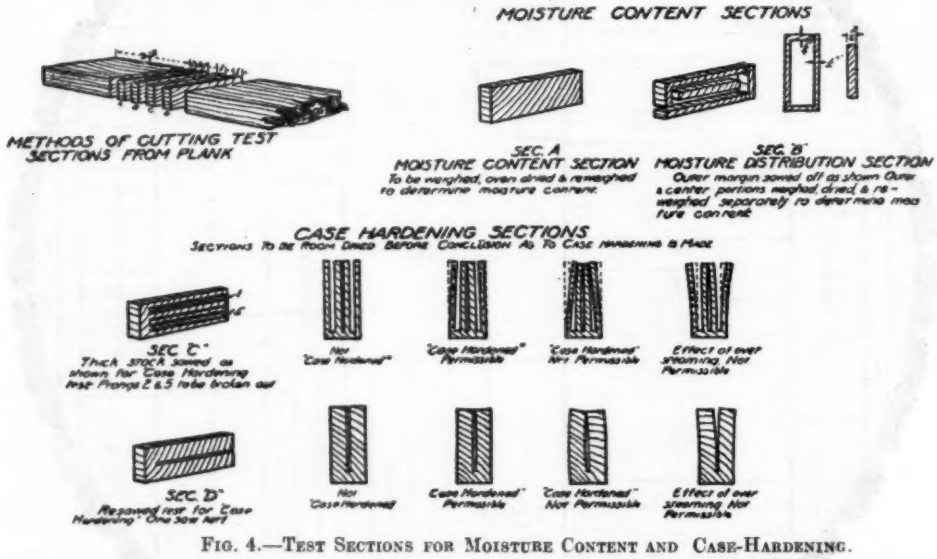

MOISTURE CONTENT SECTIONS
METHODS OF CUTTING TEST SECTIONS FROM PLANK
SEC. A
MOISTURE CONTENT SECTION
To be weighed, oven dried & reweighed to determine moisture content.
SEC. B
MOISTURE DISTRIBUTION SECTION
Outer margin sawed off as shown Outer & center portions weighed dried, & re-weighed separately to determine moisture content
CASE HARDENING SECTIONS
SECTIONS TO BE ROOM DRIED BEFORE CONCLUSION AS TO CASE HARDENING IS MADE
SEC. C
Thick STOCK sawed as shown for "Case Hardening" test Prongs 2 & 5 to be broken out
Not "Case Hardened"
"Case Hardened" Permissible
"Case Hardened" Not Permissible
Effect of over steaming, Not Permissible
SEC. D
Reasoning test for "Case Hardening" One Saw kerf
Not "Case Hardened"
"Case Hardened" Permissible
"Case Hardened" Not Permissible
Effect of over steaming Not Permissible

FIG. 4.—TEST SECTIONS FOR MOISTURE CONTENT AND CASE-HARDENING.

The drying should relieve the interior tension and cause the stresses to disappear.

(To be continued.)

The Treaty of Versailles and Public Works in France.—The programme of the first section of works of public utility, which the French Government suggests that Germany should be asked to execute in France, in virtue of Article 19a, Annex 2, of the Treaty of Versailles, shows that five schemes are planned, as follows:—(1) The harnessing of the Rhône; approximate cost 3,250,000,000 fcs. (2) The regulation of the Truyère; estimated cost 210,000,000 fcs. (3) The regulation of the Dordogne; estimated cost 270,000,000 fcs. (4) The construction of a tunnel between Saint-Maurice and Vesserhague, 3.26 km. (about two miles) long in the Vosges; estimated cost 64,000,000 fcs. (5) The construction of two parts of the North-East Canal (junction canals: Sarre-Moselle-Meuse and Meuse-Escaut); estimated cost 1,100,000,000 fcs. Total cost, about £100,000,000, including contingencies. The financial charges are to be divided as follows:—France about 19 per cent., Germany 81 per cent. The work is estimated to last four years in the case of the Truyère scheme; four years at the Dordogne; and five years at the Vosges tunnel. The scheme is being submitted to the Reparations Commission for their approval.

The Development and Manufacture of High-Tenacity Brass and Bronze.*

By O. Smalley, M.Inst.M. (Newcastle-on-Tyne).

It is intended in this Paper to treat synthetically the development of complex high-strength brasses and to consider the principal problems of manufacture. In the past these alloys were termed "manganese bronzes," and in specific cases prefixed by either the inventor's or a trade name. This no doubt arose from their complex nature and costly practical evolution. At the same time it is a misnomer and surrounds them with an air of mystery which retards rather than advances their progress.

The base of practically all the so-called "manganese bronzes" is brass, and they do not derive their special virtues from manganese. The Institute of Metals has suggested the name "brass," preceded by the name of the special elements introduced, *e.g.*, the presence of aluminium would identify it as "aluminium brass," manganese as "manganese brass," if both these elements are present as "aluminium-manganese brass," and so on. This is a step in the right direction, and the recommended appellation will be adopted throughout this Paper.

To understand the function of the numerous special elements commonly introduced, viz., aluminium, manganese, iron, nickel, etc., a working knowledge of the constitutional diagram of the copper-zinc series of alloys is essential.

This diagram is generally avoided by the foundryman and engineer on account of its formidable appearance and the adoption of Greek terms. Yet it presents a fund of information which may be readily interpreted by anyone interested.

Fig. 1 shows both the constitutional diagram and the physical properties of the pure copper-zinc series of alloys in the "cast" state.

Considering the interpretation of the constitutional diagram only, *i.e.*, the thin black lines, from lines ABCDE the melting point of any brass may be obtained; increase the temperature by 10 to 12 per cent. and a good idea of the correct casting temperature is obtained. From line AFMNOQ the temperature of complete solidification. The difference of temperature between these two lines is a measure of the range of temperature through which any brass cools during solidification. Area enclosed by AFHG, including all brasses to 37.2 per cent. zinc, shows that those containing up to 30 per cent. zinc will proceed, uninterrupted by any subsequent physical changes after solidification, *i.e.*, they will consist of a single homogeneous solid solution of copper and zinc at all temperatures. This solid solution is termed "alpha" brass, and for all practical purposes is unaffected by the rate of cooling.

Exceeding 30 per cent. zinc, another constituent appears alongside with the "alpha," and for want of a better name is termed the "beta" constituent. As the zinc content increases, the greater the quantity of the "beta" and the less the quantity of "alpha," and between 46.7 per cent. and 49.7 per cent. zinc none of the "alpha" constituent exists, but only the "beta." This is clearly shown by Figs. 3 to 6, representing 65/35, 60/40, 55/45, and 53.3/46.7 brasses respectively, cut from 2½ in. sq. ingots.

In the 30 to 37.2 per cent. zinc series of brasses the line FHG marks where they pass from a region in which both the "alpha" and "beta" phases can exist side by side into the main "alpha" zone, where this constituent alone is stable. The "beta" constituent must then exist in a metastable state, and, if normally cooled, changes into the "alpha" phase on the alloy passing through the temperature represented by that point on line FHG.

If, now, a brass of this series is quenched in the "alpha beta" area, FHIM, and the rate of cooling is such as not to permit the natural change from the "alpha beta" to "alpha," then a duplex structure will be formed, and the brass will be hardened to an amount determined by the percentage of the "beta" constituent present.

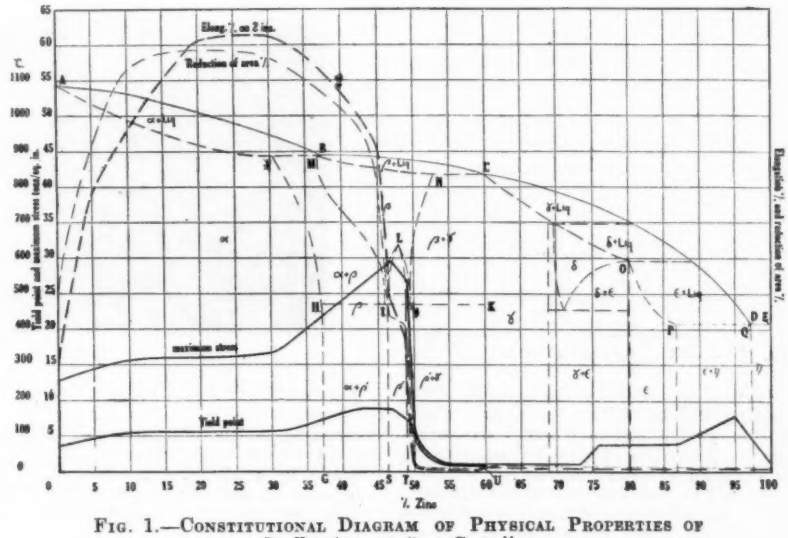


FIG. 1.—CONSTITUTIONAL DIAGRAM OF PHYSICAL PROPERTIES OF CU-ZN ALLOYS "AS CAST."

This point has been somewhat elaborated to demonstrate that brasses containing between 30 to 37.2 per cent. zinc are affected by heat treatment, and though not of practical importance, so far as improved mechanical properties are concerned, an understanding of these physical changes explains many of the defects common to these brasses. A further feature of this series is that they can be worked either hot or cold.

Exceeding 37.2 per cent. and up to 49.7 per cent. Zn a complex state of affairs exists, and the "beta" constituent remains stable at all temperatures.

The physical changes shown to take place after solidification by region FMNCUG are not strictly correct, and are subject to alteration of academic rather than practical importance. Brasses containing 37.2 to 46.7 per cent. Zn being possibly the most important series of the Cu-Zn alloys form the basis of all high-tenacity brasses, and consist of both the "alpha" and "beta" constituents. If quenched from high temperatures—*i.e.*, tem-

* A Paper read before the Birmingham Conference of the Institution of British Foundrymen.

peratures above the line IM—the change from "beta" to the "alpha beta" is suppressed. Such brasses, then, may have an all "beta" structure—*i.e.*, their physical properties may conform in many respects to brasses containing between 46.7 and

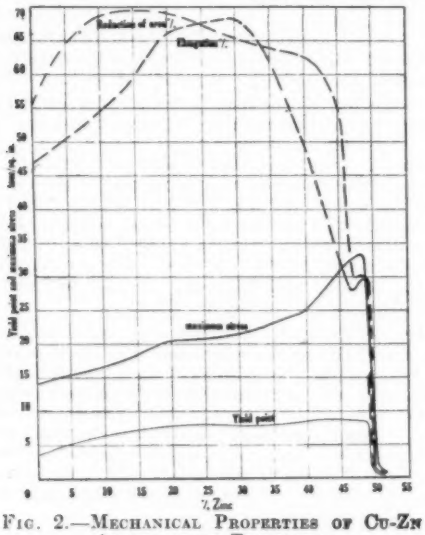


FIG. 2.—MECHANICAL PROPERTIES OF CU-ZN ALLOYS AFTER TREATMENT.

49.7 per cent. Zn. It is also evident that the nearer the zinc content to the limit 46.7 per cent. the lower the temperature necessary to effect this physical change.

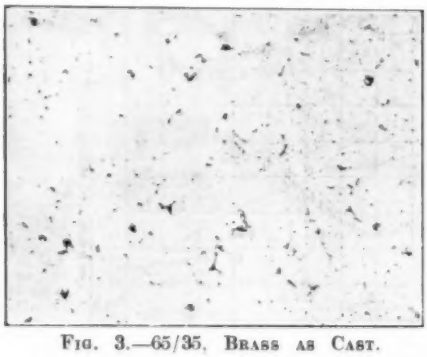


FIG. 3.—65/35, BRASS AS CAST.

The next group of alloys to be considered are those containing 46.7 to 49.7 per cent. Zn. These have little commercial value. Their constitution is ambiguous. According to the accompanying diagram, the region of true stability of "beta" brasses is confined to temperatures above 470 deg. C., and whilst it must be admitted, by the inclusion of line HI IK, that some critical change does occur at these temperatures, which the author

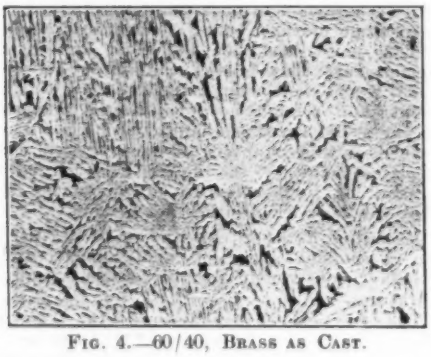


FIG. 4.—60/40, BRASS AS CAST.

has never been able to demonstrate by heat treatment alone, that they mark the transition of the "beta" constituent into its component parts, "alpha" and "gamma," as is commonly alleged. That some critical change does occur at or about 620 deg. C. is supported by:—(1) It marks the true limiting forging temperature of practically all the "beta" brasses; (2) it indicates the temperature of incipient heat fragility; (3) it is the correct annealing temperature for practically all pure brasses.

It is of interest to note at this stage that it is brasses which enter into region MIJN—*i.e.*, the "beta" brasses, which specially lend themselves to working hot, whilst those consisting of only the "alpha" constituent are peculiarly suitable for working cold.

Exceeding 49.7 per cent. Zn, a new constituent, gamma, makes its appearance. This is a hard, brittle alloy, and its inception in the most minute traces renders brass extremely brittle and useless as a material of construction. So brittle is the "gamma" phase that an alloy containing 60 per cent. Zn—*i.e.*, all "gamma"—may be crumbled between the fingers.

The thick black lines, Fig. 1, show the physical properties of pure brass, correctly cast in chill moulds; and in Fig. 2, the physical properties after mechanical and thermal treatment, such as to remove completely casting structure, internal strain and heterogeneity. In short, No. 1 may be used as a standard of the physical properties of brass castings. No. 2 to rolled, extruded and forged brass when correctly annealed.

Development of High-Tenacity Brass.

In this research constant conditions were maintained throughout, eliminating all variables except the one desired, viz., chemical composition. For this reason virgin metals and specially prepared stock alloys were used, the chemical compositions of which are given in Table 1. Two grades of zinc were adopted, owing to the uncertain test-figures previously obtained from cast-

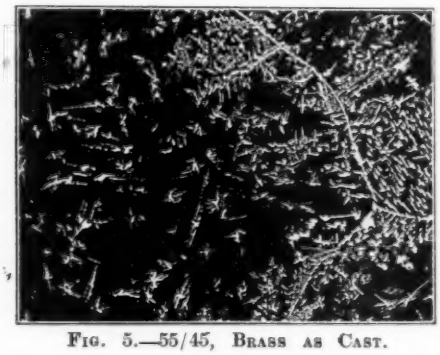


FIG. 5.—55/45, BRASS AS CAST.

ings and forgings made with the lower grades of spelter.

Owing to the difficulties of obtaining standard conditions with a sand mould, each casting was made in a 2½ in. sq. chill mould, pouring with exactly 10 per cent. superheat and controlling the temperature of the mould at exactly 130 deg. F. (55 deg. C.).

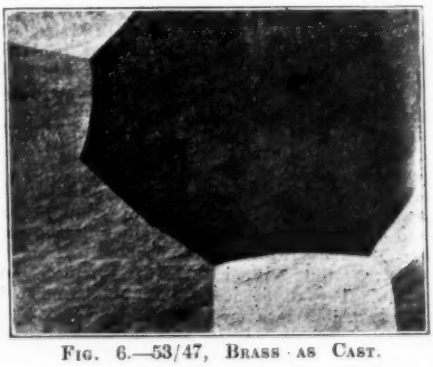


FIG. 6.—53/47, BRASS AS CAST.

Physical Tests.—Tensile tests were prepared in accordance with the specification of the Engineering Standards Committee, the area being 0.25 sq. in. and the gauge length 2 in. A permanent set of 0.01 in. is recorded as the yield point.

Hardness.—The Brinell ball-test and the Shore scleroscope were used for this purpose. The former

being made with a 10 m/m ball under a pressure of 1,000 kgs., maintained for exactly 30 sec., whilst the latter were made with a soft hammer.

In order that complete data should be obtained both regarding the peculiarities of manufacture and mechanical properties, each alloy was made under works conditions. Melting was performed in a 50 or 100 lbs. crucible, according to the size of casting, in a natural-draught coke furnace.

The method of introducing the various special metals investigated, and the precautions necessary, will be detailed under each distinctive heading. These, by no means arbitrary or exhaustive, represent a practice that has withstood the test of time and can be commended.

Mechanical Treatment.—Where it was desired to investigate in the forged or heat-treated condition, the lower half of the ingot was forged into 1 in. sq. bars. In the case of cold-working alloys, a 100-lb. ingot was cast 1.05 in. by 4 in. wide. The lower half was cold rolled in three passes to 0.55 in., annealed at the correct temperature, reduced to 0.45 in., and re-annealed so as to restore to its original "cast" Brinell hardness number before testing.

Dynamic Stress Tests.—Both alternating and single-blow impact tests were made where possible. In the former the test-piece used was 4 in. × ½ in. × ½ in. with a 1/16 in. radius groove milled in the centre of one face, at right angles to the principal axis. A steel tup having a total weight of 10 lbs. was allowed to fall from a height of 18½ in. on to the test-piece, the first blow being given on the face opposite to the groove, and, for every succeeding blow, the test-piece rotated through an angle of 180 deg. The blows were delivered at a regular rate of 25 per min., and that number taken to break completely the test-piece, was recorded as the alternating impact number. The single-blow impact test was made in the Izod machine, using the standard 10 m/m square test-piece, notched 2 m/m deep at an angle of 45 deg. and the striking hammer contacting the test-piece at a distance of 22 m/m above the bottom of the notch.

(To be continued.)

TABLE I.—*Analyses of Materials Used.*

Material.	Zn.	Cu.	Pb.	Fe.	Si.	Al.	Sn.	Cd.	O.	P.	Co.	Ni.	As.	M.
Zinc (Crescent Brand) ..	99.99	Nil.	Tr.	Tr.	Tr.	—	—	Tr.	—	—	—	—	—	—
Zinc (Crown Brand) ..	98.58	0.03	1.13	0.14	Tr.	—	—	0.12	—	—	—	—	—	—
Copper (Wallaroo Brand)	—	99.81	Tr.	Tr.	—	—	—	—	0.19	—	—	Nil.	—	—
Aluminium	—	Tr.	—	0.40	0.09	99.51	—	—	—	—	—	—	—	—
Tin	Nil.	Nil.	0.20	Nil.	—	Nil.	99.7	—	—	—	—	—	0.10	—
Ferro-zinc	94.10	0.29	1.16	4.45	—	—	—	—	—	—	—	—	—	—
Ferro-copper	—	90.00	—	10.00	—	—	—	—	—	—	—	—	—	—
Copper-manganese ..	—	72.73	0.09	2.36	0.30	—	—	—	—	0.03	—	—	—	24.35
Cupro-nickel	—	92.58	—	Tr.	—	—	—	—	—	—	—	7.42	—	—
Cupro-cobalt	—	90.00	—	0.20	—	—	—	—	—	—	9.76	0.04	—	—

TABLE I.A.—*Physical Properties of Pure Brass.*

Composition. Cu.	Zn.	Condition.	Y. P. Tons per sq. in.	M.S. Tons per sq. in.	E. Per cent. on 2 in.	R. A. Per cent.	Alternating Impact No.	Brinell hardness No.	Scleroscope hardness No.
70	30	As cast	6.50	16.70	58.00	57.00	79	55	15
		As forged and annealed	8.00	21.50	68.00	65.00	85	57	15
59	41	As cast	8.80	24.90	45.00	49.70	79	90	14
		As forged	9.00	26.00	47.00	62.00	87	90	14
		Forged and annealed, 650° C. for 1 hr. ..	7.00	24.00	49.00	55.00	—	79	12
53.3	46.7	As cast	9.00	29.70	24.00	21.50	34	108	18
		As forged	9.70	32.80	28.00	30.60	49	114	18
		Forged and annealed, 650° C. for 1 hr. ..	7.50	29.10	22.50	31.60	—	108	18
51.2	48.8	As cast	7.20	26.90	19.00	21.50	27	108	18
		As forged	9.20	33.40	37.00	33.50	36	114	18
		Forged and annealed, 650° C. for 1 hr. ..	5.30	29.00	25.00	27.00	—	108	18
50.19	49.81	As cast	6.00	8.80	1.00	1.50	1	108	18
		As forged	2.30	15.80	5.00	5.50	9	117	19

Belgian Competition in South Africa.—The Belgian Vice-Consul in Johannesburg has written a memorandum showing how trade between Belgium and the South African Union could be developed.

Proposed Iron Foundry at Bloemfontein.—The Inspector of White Labour at Bloemfontein reports that the Carron Company, of Falkirk, through its Johannesburg representative, have applied to the Bloemfontein Municipality for 10 acres of ground on the Industrial Development Sites, for the purpose of establishing an iron foundry. The Company propose to spend £20,000 on buildings.

British Iron Ore Resources.

The Imperial Mineral Resources Bureau have issued three more parts of a series of volumes dealing with the present and prospective iron-ore supplies of the world.* Part 3 deals with British America. The section dealing with Canada is based on a Special Report (dated 1920) to the Imperial Mineral Resources Bureau by the Canadian Minister of Mines, and the two volumes issued in 1917 by the Canadian Department of Mines on the "Iron Ore Occurrences of Canada"; it extends over eighty-five pages. The ores of Newfoundland are dealt with on further twelve pages. In the West Indies iron ore has been recorded only on Trinidad, and the deposits there are briefly described. No deposits have as yet been discovered either in British Honduras or the Falkland Islands. Magnetic ironstone has been found in British Guiana, and large areas in this Colony are covered by superficial deposits of lateritic ironstone low in phosphorus.

About two-thirds of Part 4 are devoted to the iron ores of the Indian Empire; the compilation of this section has been supervised by two members of the Geological Survey of India. The rest of this Part deals with the ores of (1) Ceylon; (2) Malay States; (3) Borneo, Brunei, and Sarawak; (4) Hongkong; (5) Mesopotamia; and (6) Palestine. Iron ores are fairly widely distributed in Ceylon, but they do not appear to be of any commercial importance at present. Extensive ferruginous deposits occur throughout the Straits Settlements and the Federated Malay States. Important deposits of limonite are found in North Borneo, and iron ores are widely distributed in Sarawak. More or less important ore bodies are to be found in the other territories dealt with in the volume.

With regard to Part 5, the section dealing with Australia is based on a Special Report in 1920 to the Imperial Mineral Resources Bureau through the Australian Metal Exchange and various official publications issued by the Governments of the various States. The actual iron-ore reserves of the Commonwealth are estimated at close upon 345,000,000 tons, and are described in great detail in the present volume. Tasmania is dealt with under Australia, but the New Zealand ores form a separate section based on a Special Report in 1920 to the Bureau through the Prime Minister of the Dominion.

THE offices of the Industrial Fatigue Research Board are now at 15, York Buildings, Adelphi, London, W.C.2.

* "Iron Ore." Part 3 (British America); Part 4 (British Asia), and Part 5 (Australia and New Zealand). H.M. Stationery Office. (Price of all three parts, 10s. net.) Part 1 (United Kingdom) was noticed in our issue for July 7 and Part 2 (British Africa) summarised in our issue for June 30.

American Methods of Manufacture of Malleable Iron Castings and Some Data in Connection with the Finished Product.*

By Enrique Touceda (Albany, New York).

The author of this Paper would assure you that he feels highly flattered in having received your kind invitation to prepare an exchange Paper to be read before your body at this meeting, and deeply grateful as well in having been asked to appear in person as your guest. He has read with great interest and profit many of the valuable contributions written by your countrymen that have served to so greatly enrich the literature of the metallurgy and metallography of iron and steel, and he well remembers particularly during the early days of his career how profoundly he prized and was impressed by Sir Lowthian Bell's classic, "The Manufacture of Iron and Steel," which at that time he continually read and studied with indefatigable zeal and enjoyment. It served as a constant source of inspiration, and for it the author has an affection that has in no way been tempered with the passage of time. The author's one regret is that, having received so much from you, he has so little to offer in return. In the letters received from the Secretary of the Conference Committee, and the Secretary-Treasurer of the American Foundrymen's Association, Mr. C. E. Hoyt, it was requested that the subject of the Paper cover the manufacture of malleable cast iron as conducted in the States. Their suggestion was naturally prompted in large part by the knowledge that the author has had a very close association with this industry, particularly during the past ten years, and in part perhaps by sharing in the interest that has suddenly awakened in other countries in regard to this subject. During the past year inquiries pertaining to the practical details of this process have been received from France, Belgium, Italy, Australia, and Japan. The author has had the pleasure of receiving visits from a number of engineers from abroad who have seemed greatly interested in the practical rather than the metallurgical details of this industry. These facts have been entered into principally, because it is the author's thought that if he took as a guide the character of these inquiries and the various questions that have been asked him by the visitors referred to, he would not miss by much the ground that members would prefer to see covered, rather than attempt to enter into an academic discussion in regard to the mechanism of graphitisation and other controversial matter concerning which so much has been written of late, or in dwelling on other strictly metallurgical details that have been so ably covered by many others, and particularly by Mr. H. A. Schwartz, whose book, compiled from articles he has written for THE IRON TRADE REVIEW, is about to be issued. The author is assuming therefore that for the most part it is the purely practical end of the proposition that will prove of greatest interest to you; that what you desire mainly is a more or less brief reference to those points concerning which inquiry has been made both in the lay-out and operation of a malleable-iron plant of average capacity, and supplement this with some other matters that in some cases has not been touched upon by others.

The Lay-out of a Malleable Plant.

Starting with the lay-out of the plant, the details of which should have most serious consideration, it is obvious that its correct plan will be dependent upon the plant-capacity specified, and the shape of the building site. In connection with the latter high ground should be selected, if possible, while low ground that is naturally wet and cannot be successfully drained should be shunned as worthless, for if annealing ovens are erected in such a locality annealing difficulties will prove to be perpetual. Whether the plant is to consist of one or various working units, and even if the raw materials are to be handled by means of a crane, it is desirable that each kind be stored as near to the metallurgical apparatus in which it is to be used as is both convenient and possible. It is advisable that at the sidings where the raw materials are to be discharged, the tracks be elevated on trestles of a height and length that will admit of the rapid and cheap discharge of car contents.

In the case of the moulding, face and core-sand, a saving will result if the roof of the buildings in which they are to be stored is flush with the tracks on the trestle, in order that the cars can be discharged directly through roof openings into the building or sheds, which should be constructed with this end in view. Irrespective of the size of the plant, the various departments in each unit should bear such a relation to each other that the product from the very start of operations and at each step in the process should be continuously approaching the shipping room in the most direct manner possible, in order to avoid the retracing of steps. Economy in construction will result if each separate department is dimensioned strictly on the basis of providing not much room in excess of that which will occasion quite serious congestion when running at maximum capacity. Experience has convinced the author that, in rare instances only, are malleable-iron plants ever run at maximum capacity, for when business is booming labour is scarce and inefficient, and when labour is plenty and men are willing to do a fair day's work there is a dearth of business. A little crowding therefore in the various departments can be tolerated at times that prove exceptional. The one-storey straight-line plant of fair capacity (25 to 35 tons of castings per day) with core room and shipping rooms at extreme ends, and foundry, hard-iron mills, trimming room, grinding and sand-blast room, annealing room, and soft mills in between and located in the order named, will be found convenient, and can be arranged as to permit of considerable economy in construction, while admitting of considerable flexibility as to expansion. The character of building unit, very popular at the present time in the States, is the one-storey steel-skeleton type with curtain walls, brick pilasters, and concrete foundations, with either a saw-tooth roof, or one of usual construction with sufficient pitch, and 30 ft. wide, a monitor running the full length of the building with window sashes hinged at the top to swing inward, and sashes in the curtain wall pivoted at the centre, the roof covering being of slate, slag, fabricated cement-asbestos tile, or other fireproof material. The one-storey building of this type with either style roof possesses many advantages, in that maximum visibility within is assured, ventilation is facilitated, and fire risk minimised.

Ventilation.

One of the most important items to be considered is that of efficient ventilation, particularly in the foundry building and core room. Without a constant supply of fresh air, energy of body and alertness of mind are gradually deadened as the day progresses, and when activity and vigour are lowered the effect is always noticeable in increased foundry loss on late heats, while the hazard, due to accident, is augmented.

For effective ventilation dependence should not be placed wholly upon the monitor, but it should be supplemented by well-designed ventilators, positioned in such a manner that a steady discharge of air is assured. A popular and very efficient make rotates on ball bearings—the direction and extent of rotation being controlled by a vane—with the result that the exit for used air always faces away from the wind, which, in passing, creates an active suction. These ventilators, when installed by those who understand the ventilating problem, have proved to be worth many times their cost.

* This Paper was the American Foundrymen's Exchange Paper read before the Birmingham Conference of the Institution of British Foundrymen.

Heating.

The efficient and uniform heating of the foundry proper is a problem replete with difficulty, owing to the variable conditions that must be met. During the night there is the natural fall in temperature, coupled with the condition brought about by the wetting and cutting of the sand, that produces a clammy dampness rather hard to remove by the time the men report for work in the morning. In contrast to this condition is the state of affairs that exist after a heat, when the air is filled with hot steam and a great amount of heat is radiating from the stripped castings. Some foundries of even fair size still use the salamander, which while very cheap to install is expensive to run, takes up space of value, interferes somewhat with crane service, and occasions loss of time due to the men congregating around it if they feel slightly cold. One of the best and most approved systems is to force warm air into the building through pipes properly spaced to yield uniform heating by one of the many blower systems now on the market. Live and exhaust steam from the power house or from a separate steam source designed for heating only, or from such a plant supplemented by steam from waste-heat boilers, is used in some plants in manifolds hung in such a manner as to be out of the way but as near as practical to leakages of cold air from windows, entrances, etc., in order to heat this air as it filters into the building. The author has seen many plants where a waste-heat boiler-installation has proved to be a mistake. A waste-heat boiler has not been designed to date in such a manner that after furnace operations have ceased it can be hand-fired economically. In running but one heat per day, any saving would be offset by the huge amount of coal required to keep up steam for the balance of the time, when power or heat was required, while if the boiler is allowed to cool off and electric power and steam for heating derived from a small auxiliary heating plant substituted, the maintenance cost, due to the strains set up, would prove disastrous. The scheme works out very nicely in other cases, especially where the cost of electric power or coal is high; where two heats per day are run from the same furnace; where one boiler is used in common with two furnaces, and particularly when a great amount of power is required for sand-blasting purposes. Reference should be given to that type of boiler least affected by quick changes in temperature.

Foundry Floor.

The foundry floor is another item that is deserving of some thought. Some favour the concrete floor, but the writer believes that if a vote were taken of the moulders the decision would be in favour of almost any other type. The concrete floor is unquestionably hard on the feet, and dangerous in some particulars. When spills occur an eye can be lost or serious burns sustained due to the instantaneous generation of steam from the moisture on the floor surface, which invariably is more or less wet. Serious accidents have occurred in the carrying of iron through the moulder slipping on the rounded particles of metal that have been occasioned by spills. Even when the floor has been properly laid, it subsequently can be ruined through carelessness on the part of the moulder in shaking out the castings too hot. However, the worst feature of the concrete floor is its great tendency to transmit vibration. When bumpers or vibrators are used, the probability of shaking down dirt from the cope or the cope itself is great. A floor of hard-wood blocks properly laid on a sand foundation yields better all-round service, and is equally good for the gangways or, if protected with a little packing where the pots are dumped, for the annealing room; but when used in the annealing room a strip paralleling the front of the oven and 6 ft. wide should consist of square annealed iron plate about 18 in. by 18 in., with lugs on the under side, and set in concrete, or smooth granite block, set in concrete and well grouted. Molten iron has no other effect on wood block than to produce a surface char, which defects are very shallow, and when present become filled and well protected by sand. Black-gum, maple, beech, southern yellow pine, if well creosoted, give splendid wear. The blocks should be laid in straight parallel courses, with the grain of the wood vertical, care being taken to keep straight courses and close joints. All courses should break joints alternately by a lap of at least 2 in., and filled with a hot, low-melting-point pitch of a consistency that will flow like water, to the end that all crevices will be completely filled. Against the sides of the building and around all foundations expansion joints should be made by placing a 1-in. by 4-in. tapered board on edge against the sides of the building and around foundations, which boards subsequently should be removed after the blocks are laid and rolled in order that the void can be filled with hot asphalt to within ¼ in. of the wearing surface of the floor. The dirt, or clay, foundry floor is the safest, and the one that is most popular with the moulder. It is comparatively inexpensive, and, if given proper attention, can be kept level and in excellent condition, while if a standard travelling sand-cutter is used, there will be no danger of the floor being cut, provided precaution is taken to see that the treads of the wheels are made sufficiently wide to prevent their sinking into the ground.

Sand Cutting.

The author believes that if the moulder was asked what constitutes at the present time his hardest and most exacting task, if casting surface is a vital proposition, he would state, "cutting sand." In this country it is getting increasingly difficult to employ moulders owing to the all-round disagreeable nature of the work and the conditions under which the work is done, coupled with the fact that an equal wage can be earned in other occupations where the work is much less arduous as well as much cleaner. It is very noticeable after a lengthy shut-down that in general those moulders who have secured jobs in other lines refuse to return to the foundry on the resumption of operations. The fact is being recognised that something must be done to lighten greatly his labour and make his living conditions within the plant square as far as possible, both in wage and comfort, with what obtains in the case of other industries, or, failing which, a very high premium will have to be paid to secure such labour. That the standard type of travelling sand-cutter has not been more generally used is due to the fact that moulding conditions in the malleable-iron foundry are different from those existing in foundries where other types of castings are made. As in malleable-iron practice, there are usually moulds on the floor between heats, it has been found impracticable in most instances to run the machine from pile to pile owing to the very short time available and the confusion that would result if this was attempted. In order to overcome this difficulty, a cutting machine has been devised to operate as a unit with a mono-rail hoist, to which it is attached by two hoisting cables, and by means of which it can be lifted to clear the ground. It also differs from others in that the operator rides on the machine, where he can easily control the cutting, piling, and traversing. Through this arrangement the operator can raise the entire outfit, himself included, and hop the machine from floor to floor without in any way disturbing the line of moulds already in place and located to one side of the pile to be cut, or encroaching in any way on the gangway space or interfering with the progress of other operations.

Lighting.

It would be difficult to over-estimate the importance of providing the foundry and other departments with proper and effective natural and artificial light. If the roof is of the saw-tooth type, the longitudinal axis of the building preferably should point to the north, while if the roof is provided with a monitor, the longitudinal axis of the building preferably should lay east and west. Not only should there be plenty of window space, but equally important means should be taken to secure a maximum amount of light from the space available. It is often found to be the case that considerable money will have been spent for the securing of ample window light, and this nullified in large part through subsequent neglect. Ribbed glass will transmit much more light per unit of area than will plain glass, while it will lessen, though at certain distances not wholly prevent, glare. It is perhaps slightly more difficult to keep

clean than plain glass, but if given systematic and intelligent attention, no trouble will be experienced in this direction.

If accumulations of dirt are allowed to remain on glass of any kind for undue lengths of time the surface will become pitted and eventually more or less opaque. The matter of artificial lighting is one that, to be handled correctly, should be placed in the hands of an expert. In this country the problem is simplified by reason of the fact that all one has to do is to avail oneself of the opportunity offered by the General Electric Company, who, upon receipt of plans of buildings and working conditions within, will advise, free of cost, the most suitable installation. While the New York State Industrial Commission have rules relating to the artificial lighting of factories, these cannot be accepted as a guide, as their requirements fall short of what is recognised as being really proper and efficient illumination for the particular character of work covered in their specification. They have had in mind, for the most part, the safeguarding against accident rather than a scientific consideration of the illuminating problem. The General Electric illuminating engineers, depending upon the character of work to be done, recommend from 3 to 6 foot-candles, corresponding to a power requirement of 0.5 to 1.0 watt per sq. ft. of floor area, which is more than double that required by the State. The dominant object to be attained is the securing of uniformly diffused light free from flicker, and in which both shadow and glare will be reduced to the minimum. In the higher bays a more concentrated distribution of light is desirable, and should obtain, than in the lower bays. These should be located at a height above the crane carriage, in the event that a crane is used, such as will admit of their being relamped and cleaned from it. The equipment that has given general satisfaction in this country for industrial lighting is that which is known as the R.L.M. standard dome reflector, bowl-enamelled incandescent-lamp, but a study of local conditions and building design and interior surface is essential in order to obtain the most efficient location and combination of overhead suspended and wall-bracket suspended units. All lights should be arranged as for quick re-lamping and cleaning, and for economic reasons too much attention cannot be given to the latter, and for the same reason the units should be so controlled that as few or as many lights can be turned on as are required at any time.

Handling Materials.

The following hints may prove of some value in the layout of a straight line foundry of medium capacity. A mono-rail crane so located that it passes from end to end of the foundry building and directly over two air furnaces symmetrically distanced as to moulding space and set crosswise of the building, in combination with an electrically-driven 2- or 3-ton transfer bridge of 30 to 40 ft. span that will admit of easy and rapid exit out of and entrance into the foundry, will pay for itself within a reasonable period. Through the latter arrangement the air-furnace charges can be placed on the floor space beneath the bridge at its entrance to the building, to be subsequently taken to the furnaces as needed. Such a scheme yields fairly complete crane service to both yard and foundry, while for a slight additional expenditure the mono-rail can be extended to the other departments if, as should be the case, a uniform overhead clearance of at least 15 ft. has been provided throughout the entire building unit. While the shortcomings of the mono-rail crane are due to its lack of flexibility in that the carriage is confined to one track, still, through appropriate special contrivances, it can be used to handle material surprisingly distant from its line of travel.

If it is deemed expedient to have a waste-heat boiler, the two air-furnaces can be placed in the middle of the foundry about 20 ft. between centres, their longitudinal axes lengthwise with the building and in the path of the transfer bridge, in order that they can, through this arrangement, be charged directly by it. One waste-heat boiler and stack can then be used in common by the two furnaces. In this design, however, the mono-rail can conveniently cover but one-half the length of the foundry building, owing to interference occasioned by the boiler and stack.

In one type of mono-rail a novel feature consists in the ability of the operator to raise or lower himself through means of a telescopical arrangement. The cables connecting the controllers for the various motors all are arranged with a flexible connection in order that at all times the operator has control of the travel and hoist motor and the motor for hoisting himself.

Through this arrangement it is possible for the operator to pick up any character of load in the yard without the aid of an assistant and bring it into the foundry, or, if in the foundry, do much work that otherwise would require the use of an additional man. In larger foundry units, it will be found that a more ambitious system of crane service not only should be adopted, but is demanded by conditions. The travelling-bridge crane service for the malleable-iron founlry differs in the majority of cases from what should obtain in the case of the grey-iron foundry, for it is rarely used for drawing patterns or for handling finished moulds. In some malleable-iron foundries, however, such as those making heavy railway work, while the requirements are quite similar, it is for a different reason. The large bottom-pouring ladle is now being quite generally and successfully used for the pouring of moulds for this class of work. The latter and former condition call for a creeping speed of from 1 to 5 ft. per min. Pouring metal through a nozzle from a large ladle suspended from a crane and passing from mould to mould necessitates quite careful control of the speeds. Consequently, the creeping and hook speed particularly should be adapted to the character of work to be done. In the absence of a specific design of building, it is not possible to indicate the best arrangement of travelling crane and supplemental crane installation. Such details are familiar to the structural engineer, and are not as serious as those to which reference has been made, if to these be added the fact that any crane should have a positive system of mechanical brakes, have electrical equipment as simple as possible, and so constructed as to prevent the admission of dust or dirt.

While, some few years ago, direct-current for crane service had numerous advantages over alternating current, electrical-control equipment has been developed to such an extent that either D.C. or A.C. current can be used with satisfactory results on slow speed. In the case of D.C. current, dynamic-braking is used for lowering, and with A.C. current regenerative-braking with solenoid load-brakes for creeping-speeds are used.

Lifting Magnets.

The lifting-magnet, used in connection with the crane, in the writer's opinion, is an indispensable accessory when the present labour situation is considered. Those who have seen labour sweat and toil in hooking-out hot castings from steaming sand, need not be told that this constitutes a very disagreeable task, and one, for reasons already cited, the men should be relieved of. Aside from this, when the castings are hooked-out and piled, much burnt sand is left in a heap on each floor that subsequently must be collected from all the floors in use. By means of the magnet not only can the castings be quickly removed, but the core wires, the cores themselves for the most part, and the chills are removed at the same time, and the entire mass deposited at one, or a few convenient places, from which the burnt sand can be easily and quickly taken to the dump, and the wire and chills recovered. Also, much time can be saved the moulder, particularly in the rapidity with which the sand cutter can get to work. It is needless to dwell on the many other uses to which the magnet can be put; in quickly loading the castings on to the trucks, that are pushed by hand, handled by the shop-mule or tractor, as the case may be, to the hard-iron mills, while its use for handling of pig and scrap is obvious.

In the event that the plot of ground is somewhat square, a rather convenient layout of building is in the shape of a very deep channel, one leg consisting of the foundry building, mainly, say, 300 ft. long by 136 ft. wide (1,300 to 1,500 sq. ft. of moulding space per ton of castings, the sq. ft. depending upon whether the work is heavy or light), the other leg containing, for the most part, the annealing room, say, 300 ft. long by 95 ft.

wide, while the web, a building 300 ft. long and 50 ft. wide, connecting and opening into the two buildings that form the legs of the channel. The situation can be easily understood by reference to the arrangement of the departments as given for the straight line plant by simply considering that the straight line is bent in the form of a channel, the various departments following in the same order as in that construction. Through this design there would be a court about 70 ft. wide to provide light and ventilation, and in which a wash room can be built, easy of entrance from any of the main buildings.

Large Plants.

For a somewhat larger plant with more furnaces, where the shape of the plot approximates the letter "T," the entire foundry building can be built like a rather shallow, short-legged, long-webbed channel, the annealing room and other departments being contained in a building in the centre of the court at right angles to and opening into the web and extending considerably beyond it, thus giving the buildings as a whole the shape of the letter "T." The foregoing layouts are simply cited as cases that have proved to be convenient in operation and flexible for either low or maximum production.

Both the hard and soft mills should be so installed that they easily can be filled by hand or power, and high enough to clear a truck if placed directly under them to receive their contents.

Black-Heart Malleable Iron.

A description of the black-heart malleable-iron process has appeared in so many papers that have been written within the past few years that the author feels certain members must all be very familiar with it. On this account a very brief explanation only will be given. The castings, as cast, whether made in the cupola, air-furnace, open-hearth or electric-furnace, must not only consist of white iron in which no trace of primary graphite exists, but in order that the finished product, after heat-treatment, be of normal fracture and superior in mechanical properties its composition must lie between certain definite limits. The white-iron composition that the author would recommend for best all-round conditions, embodying facility of conversion, fluidity, shrink, static and dynamic strength, and ductility in final product, is of necessity and for obvious reasons a compromise. Such a composition is:—Silicon, 0.90; phosphorus, 0.20; sulphur, 0.060; manganese, 0.25; and comb. carbon, 2.35 per cent.

Later, some remarks will be made concerning permissible limits, but while at this point, the author desires to explain that the recommendations he will give in regard to both melting and conversion are based upon works conditions and not upon what can be accomplished by a scientist in laboratory apparatus of easy and positive control. In the States the cupola is little used except for castings for fittings. Melting the charge in the presence of coke in the ordinary cupola means not only high-sulphur but high-carbon. The mixture is one in which sprue and malleable scrap predominate; some steel may be used, and enough pig added to bring the silicon to the required point. The mixture as it enters the cupola will run from 0.70 to 0.95 per cent. silicon; the total carbon from 2.50 to 2.75 per cent.; the manganese in the neighbourhood of 1.00 per cent., the phosphorus under 0.18 per cent. The loss in silicon is but little, rarely as much as 0.12 actual, the loss in manganese about 2/5 the original content; carbon will be picked up to an amount that will produce an average of 3.00 per cent. in the product, while the amount of sulphur in the product will be a function of the fuel ratio, the quality of the coke, the amount in the original mixture and the size of the scrap. The smaller the scrap the larger will be the gain in sulphur. In the fittings examined by the author the sulphur will average around 0.25 per cent. While such iron, when annealed at a high temperature, will produce a free-cutting product, and while it is acceptable as a material for fittings, it would show a very abnormal structure in sections at all heavy, while it would be very low in elongation.

(To be continued.)

Publications Received.

KELLY'S DIRECTORY OF THE MERCHANTS, MANUFACTURERS AND SHIPPERS OF THE WORLD. Published by Messrs. Kelly's Directories, Limited, 186, Strand, London, W.C.2. Price of the two volumes 64s., post free.

This is the thirty-sixth annual edition of Kelly's Directory, and its two volumes contain some 5,000 pages and relates to no less than 20,000 foreign and colonial cities and towns, under which over 1,000,000 trade descriptions are given.

The directory is in two main sections, the first dealing with foreign countries and the second with the British Commonwealth. Under each town-heading, classified and alphabetically arranged lists are given of all engaged in trade, together with the class of goods in which they deal. The index and instructions for using the directory are given in four languages—English, French, Spanish, and German. The maps, brought up to date, of all the principal countries have been retained.

THE METAL INDUSTRY HANDBOOK AND DIRECTORY. Published by Louis Cassier Company, Limited, 34, Bedford Street, London, W.C.2.

This year's edition differs materially from previous editions by the incorporation of a ferrous section. This new portion comprises tables of weights for various shapes and sizes of cast iron, wrought iron, and steel, standard specifications for steel, Admiralty and aircraft specifications. The load equivalents in British and metric measurements ranges from 19.6 to 42.5 tons.

STAVELEY COAL & IRON COMPANY, LIMITED, Chesterfield. Monthly stock lists of cast-iron pipe for July.

MESSRS. AUTOMATIC & ELECTRIC FURNACES, LIMITED, 281, and 283, Gray's Inn Road, London, W.C.2.—Catalogue dealing with Weld-Barfield Automatic Electric Hardening Equipments.

INDUSTRIAL WELFARE SOCIETY, 51, Palace Street, London, S.W.1.—"The Human Factor in Industry," by Robert R. Hyde.

Book Review.

ALL ELECTRIC AGE, by Adam Gowans Whyte, B.Sc. Published by Messrs. Constable & Company, Limited, 10, Orange Street, Leicester Square, London, W.C.2. Price 7s. 6d.

This book is of a popular character and is designed to place electricity in its proper degree of importance in the eyes of the layman. No mathematics are given nor is the matter treated at all from a text-book standpoint.

The book is divided into fourteen chapters and is well illustrated and indexed. For the layman, the book will open up an important vista, which under modern conditions of industry should be realised by everybody.

Canada and European Imports.—A cable from Ottawa states that an announcement has been made regarding the operation of the new Depreciated Currency Law, designed to prevent dumping, which provides that the value for duty shall not be less than the value of similar goods produced in the United Kingdom, and that if similar goods are not produced in the United Kingdom, the value for duty shall not be less than the value of similar goods imported from any European country in which the currency is not substantially depreciated. According to Departmental instructions issued to collectors of Customs, the new order will apply to goods from Germany, Austria, Hungary, Yugo-Slavia, and Russia.

British Association.—The arrangements for the autumn meeting of the British Association, which begins at Hull on September 6, are now well advanced. Sir Charles Sherrington will be the President for the year. He is also the President of the Royal Society. The Association is making a special effort this year to secure an increased attendance of the younger scientific students at the meeting. Part of the income from the £10,000 of War Stock lately presented to the Association is to be used for this purpose, and a certain number of British Association Exhibitions have been offered to the Universities and University Colleges, the Senates being asked to nominate students not higher than the B.Sc. degree. The Exhibition will give the student his travelling expenses and his membership.

XUM

The Training of Foundrymen.*

By A. A. Liardet.

Modern Conditions.

It is an indisputable fact that at the present moment the very greatest difficulty is experienced in finding boys willing to be apprenticed to the art of moulding.

If this state of things continues—Necessity being the mother of invention—moulding will cease to be an art, and will degenerate into a mere mechanical process, carried out by workers depending on the brains of the pattern-maker and the mechanic.

The average boy is almost invariably interested in all things mechanical, but is rarely attracted by the outwardly drab occupation of playing with dirty sand, which is how the moulder's occupation is looked upon by the outsider, all ignorant of the skill and experience necessary to become a proficient foundryman.

This being the case, it becomes almost the foremost duty of an organisation such as the Institution of British Foundrymen to consider, and, if possible, recommend for adoption, means by which foundry work and its various branches can be made more attractive to the average boy just ready to leave school.

We should go a long way towards accomplishing this if we could adopt in our foundries in conjunction with the local Technical Institutions, a system of training which would afford equal facilities to every class of boy entering a foundry, to attain before the completion of his actual apprenticeship—by his own exertions and proficiency—a knowledge of the higher branches of foundry work, such as metallurgy and the selection of materials.

Co-operation of Technical Schools.

In the past, technical schools have not catered for the training of the foundryman, but of more recent years several of the larger establishments have been running a course in this branch of engineering, and it is now the wish and intention of the Bradford Technical College to inaugurate such a course in conjunction with the foundries of the district.

When considering the question of any sort of training the first point to make clear in one's mind is the final result we wish to achieve. What is the object of the training? What are we aiming at to produce?

The Raw Material.

Training is a process of evolution, the shaping of raw material into some desired finished product, by means of carefully planned out progressive steps, very similar to any process of manufacture from the raw material to the finished article.

The materials upon which we have to work in this case are human beings—material sometimes presumed to be of a standard specification, but when subjected to analysis, of widely varying qualities, both physical and mental.

Any scheme therefore, which we may suggest, while keeping the ultimate desired result always in view, must provide for dropping unsuitable material into its proper grade, after having given it repeated opportunity to take the polish necessary for the next step in the evolution of the desired finished article.

It is useless to continue work on material, when that material is incapable of taking the preliminary polish.

Our system therefore, must also include an examination of this material, at a very early period of its evolution, to avoid the danger of throwing on to the scrap heap material which might have been suitable for some other purpose, but rendered useless owing to the fruitless work that has been done upon it.

Having determined these points as axioms in the problem of the Training of Foundrymen, our next task is to decide on the final result we wish to achieve, and the various gradings into which we shall have ultimately to consign our raw material, according to its capabilities of absorbing the training we are going to impart to it.

The diagram indicates the author's idea of the grading of the finished product, together with suggestions for the necessary training to produce it.

Doubtlessly many will recognise a similarity between this diagram and one that was published by the Engineers' Advisory Committee to the Bradford Technical College for the training of civil, electrical and mechanical engineers. This latter scheme has been adopted in a modified form, by most of the engineering shops in Bradford, and the experience gained from its adoption enables me to put forward this present scheme avoiding many of the difficulties which arose with the original.

Probationary Period.

Adopting the principle of grading, or more correctly, selection, we start by bringing a boy into the foundry between the ages of fourteen and sixteen, telling him that he is on probation until he reaches the age of sixteen, that until then, he will only be called upon to do light work, will have every opportunity of making himself familiar with foundry work, learning the routine, and observing the conditions under which the foundryman spends the greater part of his day. We further tell him that at the age of sixteen he will have to pass a simple test examination in mathematics, engineering science, and engineering drawing, which he must study at the branch schools evening classes.

We also make it quite clear that he is under no obligation to enter on a trade apprenticeship, nor do we bind ourselves to take him as an apprentice if he is not fit physically or otherwise, to follow the calling of a foundryman.

Here we have our preliminary grading or selection. If a boy fails to show a sufficient knowledge of the elementary subjects mentioned above, or is unsuitable for foundry work, he has to choose some other trade. At the early age of sixteen no harm is done, he still has ample time to take up and learn some other subject.

Ability to Read Drawings Essential.

At this point the author cannot emphasise too strongly the absolute necessity for all foundrymen to have some knowledge of engineering principles. How many otherwise most excellent foundrymen of to-day are hampered by their inability to read a drawing? How often does it happen that it is only when the pattern is in the foundry, or worse still, when the casting is made, that the foundryman can point out obvious errors in design leading to cracked or drawn castings.

On many occasions since the formation of this Branch has the opinion been expressed, that half of the foundry wasters are made in the drawing office. This is only too true, and implies a lack of co-operation between the designer and the foundryman, or more often, because the foundryman has not thoroughly understood the drawing when it was shown him.

It is for this reason that it is desirable to include a knowledge of engineering drawing, or at any rate an ability to read simple drawings, as a necessary qualification of the would-be foundry apprentice, and advocate continued instruction in this subject during at least the first two years of apprenticeship.

Trade Apprenticeship.

This preliminary grading having demonstrated that the boy is satisfactory, he commences his Trade Apprenticeship approximately at the age of sixteen.

Nothing definite can be said at the moment on the advantages or disadvantages of apprentice indentures, or what is often termed the binding of apprentices. It is only reasonable that if employers agree to give facilities to boys to take such a course of training as is laid down here, they should ask for some form of assurance that the young man will not run away before they have obtained any real benefit from his services, as soon as an opportunity presents itself for him to improve his position.

On the other hand, if the training is attractive enough and the youth really in earnest, no such temptation should ever arise.

* Paper given before the West Riding of Yorkshire Branch of the Institution of British Foundrymen.

From 16 to 17 the practical work in the foundry would consist of light sand core-making, and light bench moulding.

In many foundries it is the custom to put the apprentice with one or more experienced moulders as a helper, often working on heavy and intricate moulds. This appears to me a case of trying to make him run before he can walk.

During the probationary period he will have had sufficient opportunity to learn the root principles and methods of moulding, so that when given a small pattern or core box he should know, at least, what he is expected to produce from it.

Every foundry foreman should select one of his assistants, either an under-foreman or charge hand, whose especial care it should be to generally supervise the work of all apprentices. In large foundries, where many apprentices are employed, it would be quite reasonable to appoint a thoroughly skilled practical moulder whose sole duty would be the supervision of apprentices' work.

The art of founding is one of the most ancient. Its secrets and mysteries have been handed down from generation to generation. In a constructive art of such antiquity there must of necessity exist many traditions—not only many traditions, but many conflicting traditions. The present-day student of the art is likely therefore, if not supervised by one selected workman, to be at the mercy of many conflicting and erroneous traditions, gathered from the many instructors with whom he would otherwise come into contact.

Naturally, the descipline of the foundry would have to be maintained, and any such supervisor would not control what the apprentice should do, but only how he should do it.

During this period the technical training would consist of mathematics, engineering drawing and chemistry. By mathematics it is not intended to convey that instruction would be given in analytical or geometrical conics, integral calculus and all the other advanced subjects covered by this term, but rather plain applied arithmetic, simple algebra and geometry, all to enable the student to understand engineering drawing and the simple calculations entailed in chemistry. The statement is advisedly made that this instruction should be taken at evening classes (or on one half-day per week), because at this juncture it would be going too far in saying that we recommend day classes without having consulted employers on their views on the subject.

Day Classes Preferable.

It should be stated, however, that the day class is more satisfactory in every respect. Not only has the employer a definite control over the attendances, as he can insist on the apprentice attending, and call for reports of his work, which he cannot do in the case of voluntary evening classes, but also it is far more likely that the boy will derive greater benefit and learn more, from instruction given to him after only having done a few hours' manual work, than he would at the end of a full day's work.

During this period it is considered inadvisable to include any subject touching on actual foundry work, as the apprentice will have quite sufficient new ideas to absorb regarding foundry practice during the day. Chemistry only is introduced, additional to the engineering drawing and mathematics, a knowledge of which is so essential to the foundryman.

The chemistry would be of such an order as to serve as introductory teaching to metallurgy, which appears later in the course.

Practical Side the Most Important.

From the diagram it will be seen that no further definite selection takes place until the age of 19. A process of automatic grading, however, is taking place. From 16 to 19 a steady progressive course is recommended, the apprentice being gradually advanced on to more important and intricate moulding, while his technical instruction carries him up to simple metallurgy with a knowledge of the various melting and refining processes.

Examinations would be held at the end of each session, and reports furnished on the progress made in the foundry.

Failures at examinations would necessitate the student continuing instruction in the subjects he has failed in, instead of progressing to the more advanced work of the next year.

This would constitute the grading, but would give boys who develop late, a chance of reinstating themselves at the next examination, and enabling them to continue with the others on the progressive course.

A second failure would naturally point out the inability of the boy to absorb technical instruction, but even this would not debar him from continuing on a lower grade course, or if he preferred, from dropping class work altogether.

Our system is such, that during the whole of this period he is learning the trade of a skilled

Age.	14	15	16	17	18	19	20	21	
Practical Training.	Boy can Start any time between the ages of 14 & 16. Employed in Foundry on Light Work, handling of Patterns, with every opportunity to see Pattern Shop work. Not finally Apprenticed until age of 16.			Commences Trade Apprenticeship Moulding and Coremaking. Light Sand Core and Moulding Work.	Continuation of Trade Apprenticeship. Advanced Core Making and Moulding Work in Sand.	Continuation of Trade Apprenticeship. Heavy Sand Moulding. Loam Moulding.	HIGHER GRADE. Moulding Six months. Furnace Work. Metal and Sand Mixing. LOWER GRADE. Continuation of Trade Apprenticeship to Moulding or Coremaking.	HIGHER GRADE. Moulding Six months. Laboratory and Research Work. LOWER GRADE. Continuation of Trade Apprenticeship to Moulding or Coremaking.	Progress made in Shop Work will be taken into consideration in conjunction with result of yearly examinations for decision as to subsequent disposal.
Technical Training.	Mathematics. Engineering Science Engineering Drawing. At Branch Schools. Evening Classes. Test Examination for Fitness to enter Technical College on Apprenticeship.			Mathematics. Engineering Drawing. Chemistry. Two Nights a Week at Evening Classes, or on One Half Day per Week.	Theory of Pattern Making from Drawings. Simple Metallurgy. Chemistry. Two Nights a Week at Evening Classes or on One Half Day per Week.	The Blast Furnace Grades of Ore and Pig Iron. The Iron Foundry Cupola. Steel Making Plant. Refractory Materials. Moulding Sands. Metallurgy. Chemistry. Two Nights a Week at Evening Classes, or on One Half Day per Week.	HIGHER GRADE. Steel Making Processes. Microstructures. Annealing. Metallurgy. Equivalent one half day per week. LOWER GRADE. Continuation of Foundry Metallurgy and Chemistry. Equivalent One Half Day per Week.	HIGHER GRADE. Advanced Metallurgy. Heat. Treatment. Alloy Steels. Equivalent one day per week. LOWER GRADE. Simple Course in Chemistry.	Annual Examinations corresponding as near as possible to the completion of each year of Apprenticeship will be held, to decide subsequent Technical Training. Failures relegate to lower grade or, if repeated, disqualification.
	Probationary Period.			Trade.	Trade.	Trade.	Lower Grade.		RESEARCH WORK. ASSISTANT FOUNDRY MANAGER. ASSISTANT METALLURGIST. FOUNDRY CHARGE HAND. SKILLED MOULDER OR COREMAKER.
				Apprenticeship.	Apprenticeship.	Apprenticeship.	Continues Trade Apprenticeship.		

SUGGESTED SCHEME FOR THE TRAINING OF FOUNDRYMEN.

moulder, so that his failure in technical work, and his decision to drop it, would not prevent him from completing his trade apprenticeship.

We must not lose sight of the fact that a man may be a thoroughly competent skilled moulder with very little technical knowledge beyond that which he can learn from actual experience in the foundry, although the more instruction he receives in subjects concerned in his work, the more intelligently and satisfactorily will he accomplish it.

Knowledge of Pattern-Making Included.

The theory of pattern-making and moulding referred to in the technical training between 17 and 18, will constitute a link between the knowledge of engineering drawing already gained and the principles of pattern-making and moulding.

If a boy wishes to become a pattern-maker, he should endeavour to teach practical pattern-making and moulding. Not even a moderate degree of skill can be imparted to a student in either of these subjects in the relatively short time which is at his disposal.

If the boy wishes to become a pattern-maker, he must be apprenticed to a pattern shop and learn to make patterns; if he wishes to become a moulder then he must be apprenticed to a foundry and learn to mould. There is no need for the moulder to try to make patterns, nor for the pattern-maker to try to make moulds, but there is *every* reason for the moulder to know how patterns are made, and the pattern-maker to know how moulds are made.

This, then, must be the function of technical institutions with relation to the training of foundrymen: to impart to the student a knowledge as to how patterns should be made from engineering drawings, to show by means of actual patterns the meaning of prints, cores, loose pieces, draw-backs, turn-over boards, skeleton patterns, struck-up patterns, etc., etc., bearing in mind that there is no logical reason for a moulder to know how even to sharpen a chisel or set a plane iron.

College Foundries Criticised.

A foundry department in a technical institute for the purpose of preparing moulds and running castings is a waste of money, and no exceptions are made for those establishments running a diploma or degree course for mechanical engineering, including foundry work.

The theory of moulding, however, should be taught, the theory underlying contraction, the effect of risers, chills, the difference between dry and green sand moulding, etc., etc. A small cast-iron melting plant should be available for making test pieces from various mixtures, carrying out experiments in shrinkage and other more scientific investigations in connection with castings other than the actual making of the castings themselves.

The simple metallurgy referred to would not at this period include any practical analysis; in fact, practical analytical work is not advocated until after the age of 19, and then only to those apprentices who have qualified for the higher grade course and whose attainments appear to indicate that they are ultimately fitted for occupations in which a practical knowledge of analysis as applied to foundry work, is essential.

Lectures would be given dealing with the properties of metals, the theory of the blast furnace, grading of pig-iron, the iron foundry cupola, steel-making plant, and the alloys of copper, zinc and tin.

Necessary Apparatus Defined.

Practical work would be confined to experiments such as the reduction of ores, the examination of the physical properties of various metals and mixtures of metals, as revealed by the recognised mechanical testing appliances, and possibly a few simple laboratory experiments showing how to detect the presence of certain elements in various alloys.

At the age of 19, the most important grading or selection in the whole course takes place. It is at this point that we determine by examination the progress made by the apprentice in the shop, whether he should follow, for the last two years of his training, an advanced course which would fit him, at the expiration of his apprenticeship, for the positions of responsibility in a foundry, or continue his trade apprenticeship, with such additional technical instruction as he can absorb, ultimately becoming a skilled moulder or coremaker.

Training Raises Status.

However democratic our scheme may be, offering as it does equal opportunities to all, a few only will rise, whilst others less favoured with the necessary talents will remain on the lower level, but at a level considerably higher than they would have attained without the opportunities of gaining the knowledge and experience which such a scheme as this affords.

This last consideration is perhaps one of the most important in the whole scheme. We mislead no apprentice as to what position he will be fit for on completion of his time. We continue to instil into him the fact that he is apprenticed to the trade of a moulder or coremaker, with opportunities to rise. Even if he is not successful, the existence of these opportunities must lead him to absorb a large quantity of the instruction offered for his consumption, so that he finishes his apprenticeship as a skilled craftsman, with an intelligent knowledge of the technicalities of the materials with which he works.

The higher grade training in the works for apprentices who attain the necessary standard at the age of nineteen, would consist for the first year of furnace work and practical experience in the mixing of metals and preparing refractory materials.

In the iron foundry they should be actually employed on the cupola, in the brass foundry on the mixing and melting of the various alloys, and in the steel foundry on the furnaces and annealing stoves.

Moulding of Primary Importance.

It is suggested that for approximately six months in each of the last two years, the apprentice following the higher grade should return to moulding.

In some of the projected training schemes for foundrymen, and one of the conditions laid down by the proposers, is, that the co-operation of employers should be enlisted to find employment for the highly-trained product. This, of course, is a highly impractical suggestion. A demand for such men cannot be created.

It is for this reason that the author suggests the six-months' moulding during each of the last two years, so that in the event of the apprentice passing successfully through the higher course, but not being able to find on the completion of his apprenticeship a vacancy in a position of responsibility in a foundry to which the knowledge he has acquired fits him, he will not have lost touch with practical moulding, and can take work as a moulder until a more favourable opportunity occurs for his advancement.

Works Laboratory Practice.

The last year of practical training includes laboratory and research work. A laboratory is not found in every foundry. Where such a department exists, it is undoubtedly better for the apprentice to study practical laboratory work there than in an academic institution of a similar kind, provided that, as our scheme provides, he has had instruction in chemistry and metallurgy at an institution where it is the business to teach. The average works metallurgist is far too busy a man to afford time to instruct young men in the rudiments of chemistry. In a foundry laboratory they would learn the routine of foundry analysis and its application to practice.

Apprentices in foundries not having laboratories would perforce have to be drafted as whole-time students to a technical institution having facilities for teaching practical laboratory work, and ample opportunity afforded them for visiting the laboratories of other foundries in the district.

The technical training during the last two years would consist of theoretical work in connection with the advanced practical work referred to above. Several of the subjects are enumerated on the diagram, but they are only meant to serve as an indication of the standard of work undertaken, and by no means limit the instruction to the actual subjects mentioned.

Foundry Research Workers.

In the last year a longer weekly period for theoretical work is advocated, and in exceptional cases the desirability of liberating the young man from apprenticeship and allowing him to enter some establishment where foundry research work and metallurgy are solely carried out should be considered.

It will be noticed at the foot of the last column of the diagram a suggestion for the final grading of the finished product. The type of positions which the fully-trained young foundryman ought to be able to fill. The author realises that he will incur the criticism of many of the more scientific fraternity by recommending that the training for the foundry research worker and metallurgist should be based on an apprenticeship to foundry moulding. Possibly for pure research work and metallurgy such training is not necessary, but when these have to be applied to practice, the only way the metallurgist can learn how it should be applied is by studying the methods and operations to which he has to apply it. A knowledge of the theory of music is essential to make an accomplished pianist, but he would have no use for an instructor in this subject who could not play the piano. Abstract scientific metallurgy is of little use in a foundry.

The practical foundryman of to-day is groping in a fog—not a fog of his own making—as no one can dispute the fact that British foundries have turned out castings which are second to none in the world.

It is a fog set up by the conflicting theories and dogmas of scientific advisers, who, from the mentality developed from an abstract academic training, are unable to examine the many foundry problems with that broader outlook which a partially practical training imparts.

On the other hand, we must admit that very valuable work has been carried out by scientific research, and that practical scientific control carried out by the right type of man is an absolute essential to the successful operation of a foundry. We should regard the present relation it bears to practical problems as being in the process of evolution.

Whilst the practical foundryman is dropping many of his erroneous traditions by rubbing shoulders with scientific control, scientific control is dropping many of its unappliable scientific investigations by rubbing shoulders with the practical foundryman.

Conclusions.

The scheme elaborated is meant to illustrate in principle only a proposal for the training of foundrymen. It is incomplete in many details.

The actual number of hours to be devoted each week to technical instruction would have to be decided by those accustomed to drawing up a syllabus of instruction. Whether this instruction should be given in the daytime or at evening classes would be a matter for the employer to decide, as also whether the apprentices should receive wages for the time spent at day classes, if these were adopted. Very little mention has been made of malleable and non-ferrous foundries, but the principle of training would remain the same.

It should be stated that those responsible for the organisation and control of this technical institution are willing and anxious to co-operate in a scheme of this kind, and are prepared to recommend the establishment of plant, laboratories, and syllabus to provide for a course of training similar to the one here laid down. Additionally, it would have the whole-hearted support of the Engineering Advisory Committee to the Bradford Technical College.

The author wishes to acknowledge his indebtedness to the Principal, Professor Richardson, and to Professor Charnock, for enabling him to state with confidence that such a course could be readily put into operation at this college provided certain additional plant and apparatus were installed.

If a recommendation for some such scheme—after it has been duly criticised—were made by local foundrymen, the attention of those able to put it into operation would be forced as to the desirability and necessity of its adoption.

What more fitting body is there than the Institution of British Foundrymen, to discuss, to decide and recommend, what is the best scheme for the training of foundrymen?

Discussion.

MR. BULLOCK, supporting the scheme, said that it would be necessary to advertise it very widely, to let boys know what training and chances they would get if they decided to learn the art of moulding. This would be necessary, as otherwise the putting into operation of such a scheme would not attract more boys to the foundry.

MR. SLINGSBY generally approved of the scheme, and emphasised the point brought out by Mr. Bullock. He had had some experience with instruction in practical founding as given at a technical institution, and knew the difficulties entailed. He was strongly opposed to any endeavour to teach practical founding in such an institute.

MR. W. H. POOLE said that although a metallurgist and engaged almost entirely on research work, he was strongly in favour of the works metallurgist receiving a partial training in the foundry. He was of the opinion that this would lead to what everyone wished for—the best type of practical scientific co-operation.

MR. SMITH, whilst generally approving the scheme, foresaw great difficulties in putting it into operation, especially in small foundries where employers depended in a large measure on the apprentices to get the output. Such foundries could not spare apprentices to attend technical classes, and had very little facilities for affording experience in any work other than the actual moulding. He strongly advocated the day class instead of the evening, as he knew the tendency for boys to go to sleep in the evening classes after a day's hard work. He was of opinion that no practical moulding should be carried out at technical institutes, boys only spent their time throwing sand at each other in such classes.

MR. WATSON, in supporting the scheme, said he had had actual experience in giving instruction in foundry practice, and knew the great benefit which apprentices derived from gaining some technical knowledge of the work they were engaged upon.

MR. PARKER thought the scheme would break down with apprentices working in highly specialised foundries, where they would have no chance to learn other moulding than the special work upon which the foundry was engaged.

MR. GROVES was of the opinion that the time suggested per week for technical instruction was far too short. There was so much to teach that one half-day or two evenings per week would be quite inadequate.

MR. THORNTON generally approved of the principle of the scheme, but thought there was so much in it that wanted careful consideration, that it ought to be printed and sent to all members and interested parties for their written criticisms.

MR. LOVE thought that one of the chief difficulties in obtaining apprentices to foundry work was the low wages paid. Parents could not afford to keep their boys at a trade, even with special opportunities for learning and advancement, if the wage they earned was so small.

MR. ROBINSON thought the chief objection to the scheme was that employers generally would not welcome it. Not only would it be a source of expense, but it would lead to disorganisation of the foundries, if boys were allowed to go to classes during working hours, and be moved to other jobs just at an age when they were really becoming useful.

The Author's Reply.

THE AUTHOR (Branch-President) replying to the various points raised in the discussion, said that he entirely agreed on the necessity of advertisement, but submitted that this would be accomplished through the branch schools. Headmasters of schools would be enlightened on the necessary qualifications for, and advantages offered to, boys who decided to learn foundry work. They would have to guide their early education to enable them to pass the preliminary qualifying examination to the Technical Institute at the age of 16. He reminded those who spoke against practical foundry teaching at a technical school that he had made it very clear in his paper that he was absolutely opposed

XUM

to it. He acknowledged the difficulties of the small foundry and the specialised foundry, saying that this had been recognised with reference to the training of engineering apprentices now in operation in Bradford. A suggestion had been made for an exchange of apprentices between different works, to enable all to obtain equal experience, but after consideration, this idea was not adopted. At the present moment he could only say that if such a scheme were adopted, these foundries would find a difficulty in obtaining apprentices, as they would naturally wish to go to those offering the best facilities for gaining an all-round experience. In replying to the difficulty of low wages paid to foundry apprentices, the President said that if we were considering a scheme for the betterment generally of foundrymen of the future, some sacrifices would have to be made. The employer, who would ultimately reap the benefit of a supply of better trained and more intelligent workmen, would have to put up with the inconveniences and expense of allowing apprentices to take up such a course, while the parents would have to be satisfied with the boy's reduced bread-winning capacity in order that their son might benefit by it in the future. He submitted that boys whose sole immediate object was to earn as much money as they could, were not likely to make efficient foundrymen. Whilst acknowledging the fact that the inauguration of such a scheme entirely depended upon the co-operation and willingness of the employers, he did not agree that there was likely to be any opposition from them. He felt sure that employers would recognise that it was about time that something should be done for foundrymen. Every employer realised the difficulty of obtaining apprentices to foundry work.

After the discussion, on the proposition of MR. ROBINSON, seconded by MR. JOHNSON, the following resolution was unanimously adopted:—

"That this general meeting of the West Riding of Yorkshire Branch of the Institution of British Foundrymen heartily approves of the scheme of training for foundrymen detailed in the paper given by the Branch President, and recommends the foundry employers in the area to give it their serious consideration as a means of ensuring a better supply of foundry apprentices and generally improving the status of the foundryman of the future."

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Foundry Apprenticeship Course.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Your leader, announcing the fact that a series of articles (each forming a separate lecture) is about to be published in THE FOUNDRY TRADE JOURNAL, for the benefit of apprentices, has doubtless been read with great pleasure by all who have the interests of the foundry industry at heart, for it is a practical proposition, and deserves the enthusiastic support of all. Technical journals, whilst adequately catering for those who have already embarked upon a career, have not proved attractive to the beginner, to whom the matter, being more or less unintelligible, is devoid of interest, and a series of articles on the lines suggested will undoubtedly supply a long-felt need.

It is to be hoped that foundry managers will show appreciation by ensuring that every apprentice will have an opportunity of studying the articles, and it may be possible for a list of questions to be compiled for the purpose of subsequent examination. There is no doubt that classes held in the foundry will be productive of better results than those held outside, for in connection with the former, practical demonstrations are possible, which do more than anything else to excite interest, and so make them more comprehensible. The matter, too, need not be confined to the foundry, for in the engineering shops there are many boys who are, at the moment, engaged in "blind alley" occupations, and many of these would welcome the opportunity of learning a trade, if the proposition is put before them in an understandable and attractive form.

There is no doubt that the choice of authors is a popular one, for that they are thoroughly practical men, well versed in every phase of the founding industry, is established by their many contributions to the columns of this Journal. The FOUNDRY TRADE JOURNAL is to be congratulated upon the initiating of a movement which has for its object the welfare of the industry for which it caters, and if it receives the support it deserves, the success of the enterprise is already assured.

I am, Sir,
Yours, etc.,
H. W. J.

Steel Borings and Turnings in the Cupola.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I noticed Mr. Cameron's reference in his Paper on "Semi-Steel" to my own Paper before the B.F.A. in 1916.

In connection with the use of steel turnings and borings, I have melted many tons of these both *alone* and in mixtures in the cupola. The only serious difficulty I ever met with was that of handling this material. (See *Engineer*, Nov. 27, 1916, and Aug. 2, 1918.)

The comparative ease with which steel borings and turnings can be melted in the cupola does not appear to be generally recognised. Steel in this form offers the largest surface area per unit weight of any form of scrap, and the advantage of this feature in the cupola-melting of this material will be obvious. Very finely divided turnings or borings either throttle the blast and hang up the cupola or finish up in the spark arrestor, according to the quantity used, as would be expected. I have, of course, never been able to successfully melt this type of borings.

The difficulties attached to the making of steel-mixture irons in small quantities are well known. The best course to follow in this case is that of re-melting previously melted steel scrap in the final mixture. This method, however, has the disadvantage of increasing the cost of the final mixture. The next best method to follow in making small quantities of steel-mixture iron is to use steel scrap direct in the form of borings.

I have seen, and friends have shown me, re-melted steel borings beautifully outlined in sections of castings made from mixtures containing steel borings. These borings existing in finished castings are usually hard and frequently unmachinable.

I submit, Sir, that vigorous stirring of the molten metal in the ladle is all that is required to prevent the occurrence of such hard spots. In fact, quite apart from steel mixtures, I have long held the opinion that the vigorous stirring of molten iron in the ladle would go a long way towards reducing the waster bill. In the iron foundry it is the exception rather than the rule to see the ladles of metal well stirred.

With regard to cupola-melted mixtures containing steel borings, I consider I have never had bad results directly attributable to the form of the scrap. I have been a fairly consistent user of steel scrap in cupola-melted mixtures for a number of years, and, whilst I strongly deprecate the title "Semi-Steel" and have no sympathy for extravagant claims for this material, I recommend the use of steel scrap at the present time as a delightfully cheap and easy way of producing a low silicon, low-phosphorus iron—"a good iron."—I am,

Yours, etc.,
J. E. HURST.

3, Sandilands, Troon, July 11.

CLAYTON & SHUTTLEWORTH, LIMITED, Lincoln, are supplying the L. & N.W. Railway with five large-sized "Clayton" patent water-tube boilers of curbed tube drum type, complete with superheaters, economisers, mechanical stokers and chimneys. The five boilers, which are similar to those being supplied by the firm to the London County Council for the Greenwich Power Station, are required by the L. & N.W. Railway for the Formby (Lancashire) Power Station, where developments are being undertaken in connection with the extension of electric railways.

American *versus* British Grey Cast-Iron.*

By F. J. Cook.

Rightly or wrongly, the average British engineer and foundryman considers that American grey irons of their respective class are inferior in physical properties to those of Great Britain. He bases this opinion, first of all, upon the undoubtedly poor wearing qualities of the cast iron which some years ago formed the material of the large quantities of machine tools sent to England. It was commonly said that the cast iron was so soft as to be easily cut with a pocket knife, a statement often enough literally correct.

Some Poor American Irons.

Recently, some improvement has been noticed, attributed partly to wider bearing surfaces and the application of chills on wearing parts, combined with the use of semi-steel. Nevertheless experiences are still related, in connection with the war, showing that American material frequently left a good deal to be desired. The author was familiar with an American machine supplied by a well-known maker which was commandeered by the Government for a special operation in connection with parts for large guns.

Owing to the poor quality of the cast iron the machine was constantly breaking down. No fault could be found with the design, which was excellent for its specific requirement; yet owing to the long periods when it was out of commission through breakdowns the output was less than that obtained from an improvised old machine. It was necessary to replace the broken parts with castings produced from local irons utilising the broken portions for patterns. These substituted parts proved quite satisfactory, and there was some foundation for the statement, although not strictly and literally true, that the only part remaining of the original cast iron in the machine at the end of the war was the name plate on the bed.

American Failures.

Writers of scientific papers in America frequently refer to the failure under superheated steam of cast-iron parts. This is a state of affairs unusual in England, grey iron castings being made without difficulty sufficiently strong to withstand working temperatures and pressures quite equal to those under which American castings have broken down—the composition of this more durable material being not widely different from the American irons which have proved unsuitable.

Some years ago an American technical journal with which the author was familiar regularly gave reports of burst flywheels, until at last it became quite natural to look for them with much the same amused interest as the readers of *Punch* anticipated the historical cartoon. English engineers regularly engaged in designing cast-iron flywheels up to a weight of 25 tons, having periphery speeds of not less than 100 feet per second, sometimes wondered as to the character of the remarkable material of which the American wheels were made.

Travel naturally widens one's views and extends one's knowledge, and conversely, there is a tendency on the part of the stay-at-home to become parochial and narrow. One of the results of the war has been a more frequent interchange of visits, and we on this side from a period shortly before the end of the war consider ourselves specially favoured in the visits we have received from many leading American foundrymen, whose eminence consists not only in foundry knowledge but in general accomplishments.

We hope they will pardon the amusement we have derived from the very candid opinions they have expressed in regard to us and our institution in the old days before, like the Queen of Sheba, they came to see for themselves. One American, for example, expressing the belief that British foundries were generally so badly lighted that an electic torch was necessary to find one's way about in them, and the moulding shops were so low that one had to be careful not to knock his head against the roof girders, was candid enough to say that the first British moulding shop he entered fairly took away his breath. After spending the whole afternoon in it, he regretted his inability to stay longer and see more. He discovered that he had only seen a small part of the whole, and was a little surprised at the offer of his guide that "any time he had a week to spare they would be pleased to show him the remainder." As a matter of fact, he was in the largest foundry in the world, and had no idea that so fine a concern could be found on the European side of the Atlantic.

The author has to admit that up to the present he has been among the stay-at-homes, and is quite prepared to find that his references to American practice will furnish foundrymen on the other side of the Atlantic with at least as much amusement as Britishers have derived from Americans and their opinions of Great Britain. The great purpose of the paper, however, is to furnish a basis for a good discussion, and it may be hoped that this object will be realised.

As the subject of grey cast-iron obviously is too wide to be dealt with in a single paper, it is proposed to limit its scope to the consideration of grey cast-iron made from commercial pig-irons, and cast-iron scrap melted in a cupola by means of coke, and without the addition of steel or any ferrous or non-ferrous materials introduced either into the cupola or the ladle of molten metal.

Conditions of Test Vary.

When one comes to deal specifically with mechanical tests the fact has to be faced that the conditions relating to mechanical tests for cast iron vary considerably in the two countries. Little importance appears to be attached in America to tensile testing, while the size of the transverse bars tested, differs widely from British practice. The ruling tests for cast iron may be said to comprise in Great Britain: For pipes, constructional and general engineering work for more or less rough and large character, transverse bars, 2 inches deep 1 inch thick and tested deep part down on centres 3 feet apart; for engine details other than cylinders, transverse bars 1 inch square tested on centres 12 inches apart. It is also becoming more general in the finer classes of engine work to cast the transverse bars 1¼ inches square, machining down to 1 inch square to insure accuracy. For cylinders of all descriptions, tensile bars exactly of the same material as the castings they are to represent are demanded. Practically every tensile bar has to be tested in the presence of an inspector, and the casting of the bars on the job therefore generally gives more satisfaction and prevents the suspicion which might possibly arise if the bar was separately cast without the presence of the inspector. There is a great deal also to be said in favour of the tensile test for cylinders, since the castings themselves are necessarily subjected to tension. Moreover, a tensile test gives a better indication of the wearing properties of this class of iron than any other test known to the author.

It may possibly be that the apathy with which the tensile test in America is regarded may to some extent be due to certain conditions named by Dr. Moldenke, though of that, of course, the author is not in a position to judge. Dr. Moldenke says†:

"In this country (America) you will find about 99 out of 100 testing machines that are not in proper condition for the tensile test. On the other side they calibrate the machines often, and they have their Governments to test them."

There can be no gainsaying his further statement on the same page that "for scientific investigation the tensile bar is preferable."

The reading of American scientific papers and of the technical Press conveys the impression that a tensile test going a little beyond 14.0 tons is considered worthy of special notice; certainly in Great Britain anything like this would be considered

* The Institution of British Foundrymen's Exchange Paper read at the Rochester Conference of the American Foundrymen's Association.

† American Foundrymen's Association, "Proceedings," vol. 22, p. 368.

XUM

quite mediocre. Mr. Ernest Wheeler,* representing Messrs. Crossley Brothers, Limited, Manchester, states that he has found it " quite possible, without the aid of steel to prepare and obtain mixtures of cast iron having a tensile strength of over 18 tons per square inch," and this is confirmed by other workers in the same field. The same gentleman has prepared for the author a bar cast in accordance with the specification for the " Arbitration bar," which has given a result of 17.5 tons.

Tensile Tests.

A short time ago the author tabulated his average tensile test results over a working period of 500 consecutive days. The average figure was just over 16 tons per sq. in.; no test was as low as 13.5 tons, while the highest figure reached was 19.2 tons. All the bars were 1¼ inches diameter and were cast on the castings they were to represent—not separate—and were turned down in the middle to ½-square inch area before testing. A typical range of tensile test results with this class of iron with the accompanying analysis is given in Table 1.

Table I.—*Results of Tensile Tests.*

Analysis.						Tensile test result, tons per sq. in.	Transverse test equivalent lbs. per sq. inch on Arbitration Bar.
C. C.	G. C.	P.	Si.	S.	Mn.		
0 98	2.074	0.974	1.213	0.146	0.324	14.6	5146
0·84	2.214	1.046	1.166	0.136	0.432	14.6	5146
0..80	2.410	1.140	1.40	0.134	0.453	16.1	5146
0.66	2.498	1.186	1.40	0.136	0.465	17.5	5373
0.84	2.432	0.981	1.143	0.137	0.288	18.4	5562
0.72	2.49	1.2	1.49	0.126	0.420	19.9	5600

For mechanical tests to be strictly comparable it is essential that the bars should be of the same dimensions and similarly moulded, gated, cast and tested. It may be argued, therefore, that the tensile test results given in Table I. are not comparable to those obtained by the American arbitration bar. But the author suggests that in this respect the advantage has not been with those cited. The bars were of the same dimensions as the arbitration bar, and they certainly had the advantage of static pressure due to casting head, as they were placed on the middle joint of short-stroke cylinders. They have one disadvantage, however, in that they were cast with cooler metal than if they had been cast from a small ladle direct from a cupola, while the rate of cooling is slower, owing to their having been cooled down in close proximity to a larger body of metal. The disadvantages of all these conditions were well set out in the admirable exchange paper presented by George K. Elliott to the Institution of British Foundrymen last September.

Comparisons between the transverse tests made in the two countries are necessarily hampered by serious difficulties, chiefly on account of the difference in shape and dimensions of the bars used. The arbitration bar has a diameter of 1¼ inches and is tested as cast, on centres 12 inches apart. The bars with which the author is familiar and of which particulars are given later are cast 1¼ inch square, machined down to 1-inch square, tested on 12-inch centres, and cast on to castings as previously defined in connection with the tensile test.

Constant Necessary.

In the absence of an available machine suitable for taking a bar of 1¼ inches, it has been necessary to evolve a constant which will reconcile the differences of dimensions in the two bars.

The results of the arbitration bar can be converted into those comparable for a 1-inch square bar tested on the same centre by multiplying the breaking load obtained by 0.74; conversely the result obtained on the 1-inch square bar divided by 0.74 will give the equivalent load in the arbitration bar. The formula used for obtaining this factor is given in the appendix to the paper.

In the discussion on Elliott's paper already referred to, the author gave some details of 25 transverse tests of bars giving an equivalent average breaking load on an arbitration bar of 5,300 pounds: the lowest bar gave an equivalent load of 5,146 pounds, and the highest 5,600. The minimum load is a higher figure than that obtained by Mr. Elliott with American metal having a similar silicon content, but with lower phosphorus and sulphur after undergoing the refining action of an electric furnace.

Table I. gives particulars of the transverse results brought up to an equivalent on the arbitration bar relative to bars cast on the same cylinders as those selected for the tensile example.

Keep's Tests Compared.

Although the two previous tests are not in the strictest sense comparable, there is a mechanical test common to both countries, namely, Keep's shrinkage and transverse test. The author was probably the first in Great Britain to have at his disposal a complete set of Keep's machines, and the present opportunity is gladly taken to acknowledge the great value of the shrinkage and transverse test in connection with this class of cast iron.

A rather lengthy correspondence took place with Mr. Keep relative to the working of the transverse machine with the ½-inch shrinkage bars. Mr. Keep expressed the opinion that the alignment of the machine had become affected during its transit. He arrived at his conclusion from the high results shown in the diagrams forwarded to him. In regard to these he said: " Probably we should not have a ½-inch square bar to break at over 425 pounds." Nothing could be found wrong with the machine, and as the result appeared to be borne out by other mechanical tests taken on bars of varying sizes from the same metal a few ½-inch bars were sent to Mr. Keep with a diagram of the corresponding bar in each set. The breaking loads varied from 590 to over 700 pounds. Mr. Keep replied as follows: " I did consider the high results obtained as due to your machine being out of order, but I was mistaken, as my machine gives the same results. The iron is remarkably strong: I don't know of anything as good."

In Great Britain we consider Mr. Keep knew all about the mechanical tests that American irons will stand. The results shown in Table II. of tests made with the same class of iron as those dealt with in Table I. are not only typical of results obtained by the author but of those secured by other workers.

Table II.—*Keep's Tests on Cast Iron.*

Shrinkage inches.	Transverse Breaking Load in pounds.	Deflection inches.
0.146	550	0.14
0.161	600	0.15
0.157	650	0.18
0.158	675	0.19
0.159	700	0.21
0.161	800	0.23

Thirty tests on this same size bar gave an average breaking load of 622 pounds.

The general practice differs somewhat between the two countries in regard to the allowable percentage of the chemical elements in different classes of grey cast-iron. This is undoubtedly due to prevailing differences in the irons, and not to a lack of metallurgical knowledge.

Briefly stated, some of the principal differences are as follows:

With one or two notable exceptions, practical foundrymen in America appear to pay little attention to total carbon. While carbon receives special attention and is frequently mentioned, it is only lately that total carbon has had due consideration. The quantity of combined carbon is important, but it is obvious that with varying amounts of total carbon the same percentage of combined carbon will have a different effect. Dr. Stead† has shown examples in which increases of 0.1 per cent. of graphite have reduced transverse strength by 224 pounds and tensile strength by 8 tons per square inch.

Silicon receives a great amount of attention in American foundry practice, and in conjunction with sulphur appears to be regarded as the Alpha and Omega by the purchasers of pig irons. One hears a great deal of " silicon control." In Great Britain silicon is merely considered with all the other elements entering into a commercial analysis. It must not be supposed that there is any lack of appreciation of the value of silicon, since in Birmingham—the home of Professor Turner—it is probable that more research work has been done with regard to the influence of silicon than in any other centre. A formula which

* Manchester Association of Engineers, " Proceedings," 1921.

† British Foundrymen's Association, " Proceedings," 1915.

the author has used for many years with marked success in connection with the ratio of silicon to carbon in grey cast-iron mixtures is as follows:

$$X = \frac{C}{4.26 - \frac{Si}{3.6}}$$

where X = the ratio of silicon to total carbon
C = total carbon present.
Si = Silicon present.

X = 0.9 to 1 for such work as pipes, grates, easily machined castings and general work.

X = 0.83 for locomotive cylinders and castings requiring *maximum transverse strength.*

X = 0.76 to 0.82 for steam, gas, oil and diesel-engine cylinders, and castings requiring *maximum tensile strength.*

X = 0.75 to 0.8 for chilled castings.

X = 0.85 for acid-resisting castings.

Effect of Sulphur and Phosphorus.

At one time in this country sulphur was considered the arch enemy of the ironfounder, although probably it is not taken quite so seriously as it is in America. In his exchange paper George K. Elliott considers that sulphur above 0.07 per cent. is dangerous. This does not agree with the results of Coe's* research on British irons. Coe found that sulphur within the limits of his work did not increase the brittleness of cast iron but appears to increase resistance to fracture.

In Table I. the sulphur appears in a proportion twice the amount which Mr. Elliott considered dangerous, yet it does not appear to have prevented a high degree of strength being obtained. A liberal proportion, up to 0.12 per cent., has, in the author's experience, been found to have a beneficial effect upon the wearing properties of cylinders and liners subjected to heat conditions, while no difficulty has been met with in the way of blow holes provided the metal has been melted and cast hot.

To an appreciable extent phosphorus is considered in America to be detrimental to the strength of grey cast-iron. George K. Elliott, in his paper, states " Irons of greatest strength contain only a small amount of phosphorus." Dr. Moldenke, in " Principles of Iron Founding," appears to put the limit for strong castings free from strains at 0.4 per cent. The author's experience points to the conclusion that with the strongest British iron the *distribution* of the phosphorus, provided the amount does not exceed 1 per cent. is more important than the actual quantity present. Phosphorus in a segregated form, the usual form in all weak irons, is dangerous where strengths are required, but provided it appears in the network or cellular form no detriment to strength is experienced with phosphorus up to 1 per cent. This form is assisted so long as the silicon and total carbon are restricted in the ratio appearing in the formulæ for strong irons.

Manganese Held to be Detrimental.

Agreement appears to be more general in regard to the benefit to be derived from the poling action of manganese, but the author believes that manganese to the extent of 1 per cent. or over is detrimental to good wearing properties under heat conditions. This element has a way of developing spikey crystals which break off under rubbing and prevent the formation of that highly polished surface generally regarded as the distinguishing characteristic of all good-wearing cast iron. Apparently there is much to be gained by keeping this element restricted to the proper proportion called for by the amount of sulphur present, and for this purpose manganese should not exceed five times the amount of sulphur; beyond this proportion there is a danger of the formation of manganese carbide.

Although chemical analysis necessarily forms the basis of all scientific work in regard to cast iron, it does not follow that similar analyses necessarily involve similar physical properties. It is also admitted that strong grey irons are associated with the matrix consisting of fairly large areas of well-defined laminated pearlite, relatively stiff portions of cementite and small graphite, and these formations are illustrated by typical examples in Figs. 1 and 2.

* British Foundrymen's Association, " Proceedings," 1911-12.

While the microscope is a useful adjunct to chemical analysis, the utility of the micrograph is limited; it being impossible to determine therefrom relative physical properties of specimens with mathematical precision, or to ascertain within narrow limits the relative variations. In all probability this is due to our imperfect knowledge of both subjects, and it may be hoped that further research will clear up some of these matters.

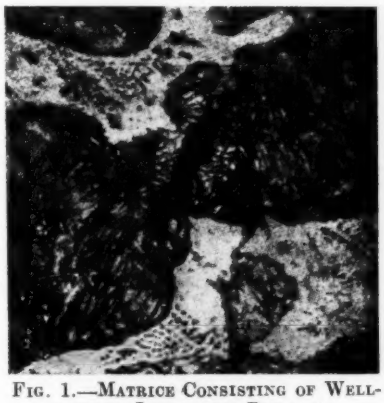


FIG. 1.—MATRICE CONSISTING OF WELL-DEFINED LUMINATED PEARLITE.

Occasionally it is quite impossible, in dealing with this class of iron, to discover either by chemical analysis or the usual methods of microscopic examination great differences in physical properties. An interesting example of this took place some time ago. It was found that the highest tensile test obtained in sixty consecutive days' workings was lower than the lowest tensile test during the next sixty days. The metal was of similar chemical analysis, but the mixture had been varied by introducing a different pig-iron brand as one of the three constituting the charge.

A research was carried on by the late George Hailstone and the author† in connection with this class of investigation. All the methods usually employed for detecting the cause of difference in physical properties, such as chemical analysis, high and low power microscopic analysis, and the employment of various etching agents, failed to show any reasonable cause for the great difference which existed.

As a further test, specimens were deeply etched with 20 per cent. nitric acid in water as suggested by Stead, and afterwards re-examined under low

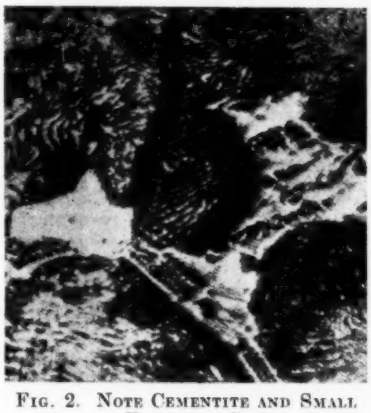


FIG. 2. NOTE CEMENTITE AND SMALL FLAKES OF GRAPHITE.

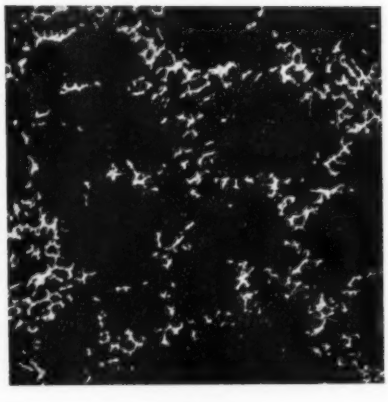
magnification. It was then found that the strength of the material was directly related to the particular formation of the cementite and phosphide eutectic. The stronger the iron, the clearer were these two microscopic elements in the network formation, as will be seen from Figs. 3, 4, and 5.

The author has made many hundreds of examinations in order to test this, and has never found a single example to the contrary. The network formation is apparent at about 12 tons tensile strength, and becomes more pronounced as the

† British Foundrymen's Association, " Proceedings," 1908-09.

strength increases. In the author's view, this method gives a surer approximation of the physical properties of the metal than any other form of metallography, and is often superior to chemical analysis. It must be remembered, however, that the field under observation must be typical of the whole. The accompanying illustrations are from micrographs taken from the centre of the bar.

In connection with the research already referred to, the authors, as one of their conclusions, decided that the temperature at which the pig iron is made in the blast furnace has a direct



FIGS. 3, 4 AND 5. MICROGRAPHS SHOWING NETWORK OF CEMENTITE AND PHOSPHIDE EUTECTICS—DEEPLY ETCHED WITH 20 PER CENT. NITRIC ACID SOLUTION.

effect upon the formation of this network structure. At the time this statement aroused a great amount of criticism, one professor stating that, after remelting, the iron had forgotten all about the hole from which it had been dug. Time has since proved the inaccuracy of this view, and it is now clear that the temperature of the blast furnace has a marked effect upon the physical properties of the metal, and that these are maintained after remelting.

One progressive blast-furnace manager has found that pig-iron having this network structure, after going through the puddling furnace, yields wrought iron with higher physical properties than is to be obtained from a pig-iron of similar analysis without this structure. He discovered further that with similar working and furnace burden the network structure was controlled by the blast temperature. When using a blast temperature of 900 degrees Fah., he is always able to get the network structure; whereas, if the temperature is increased, the network diminishes until at 1,100 degrees it disappears entirely, with a corresponding lowering of physical properties of the wrought iron, the general chemical composition of the metal being the same. As the result of these discoveries, the blast-furnace manager has now fitted his furnace with pyrometers for recording the temperature of the blast, and is able thereby to obtain more regularly consistent results.

Network Structure Increases Strength.

Another criticism by a well-known metallurgist was that, although greater tensile strengths were associated with a network formation of the cementite and phosphide eutectic, he thought the metal would give less resistance to shock or fatigue.

Rotary fatigue tests were taken by the Wheeler method by the Sheffield testing works on the bars whose structure is shown in figs. 3 and 4, and these are given in Table III. Fig 6 gives details of the method of applying the test and the dimensions of the test bar. The comparative results are even wider apart than appears from the tensile results.

TABLE III.—*Results of Chemical and Physical Tests.*

Chemical analysis	Tensile strength, tons per sq. in.	Rotary fatigue test results. Revolutions per minute	Fibre stress tons per sq. in.	Total number revolutions to produce fracture.	Appearance of fracture
	9.1	980	11	100,800	Fracture sound.
T.C. 3.25% G.C. 2.397 C.C. 0.853		980	5	10,000	Fracture sound
Si. 1.328	9.1	980	6	9,200	Slightly open.
S. 0.95 P. 0.923 Mn. 0.290				19,200	Grained
T.C. 3.192		980	5	10,000	Major Portion Fine Grain but trace unsound near periphery
G.C. 2.289		980	6	10,000	
		980	7	10,000	
C.C. 0.903		980	8	10,000	
		980	9	10,000	
Si. 1.314	18.3	980	10	10,000	
		980	11	10,000	
S. 0.101		980	12	10,000	
		980	13	10,000	
P. 0.909		980	14	10,000	
Mn. 0.335		980	15	800	
				100,800	

The fundamental law governing the phenomena of the formation of the network structure has not so far been definitely and satisfactorily proved. J. E. Fletcher, however, has furnished an explanation which has the greatest degree of probability. Mr. Fletcher is advising director to the British Cast Iron and Wrought Iron associations and has devoted much thought and research to the elucidation of this problem in connection both with the blast furnace and the cupola. His explanation is as follows:

He believes that this structure follows the original boundaries between the crystals of the metal which is first fused during the descent of the iron to the fusion zone in the blast furnace. The carbonisation of the crystals follows their boundaries as decarbonisation follows them in the mechanism of the malleablising process.

If the blast penetration effect while passing the tuyere zones is drastically oxidising, following rapid carbonisation in hot-blast furnaces, then the strong boundary intercohesion is more or less destroyed, with possible gas and oxide inclusions along the boundary films.

With the soft blast of cool or cold-blast furnaces this action is absent, and the intercohesional strength of the crystalline structure, due to the presence of combined carbon and air—unimpaired by gaseous and iron oxides and minute slag inclusions—is maintained.

Shock Test Advocated.

Points which the author has found helpful in producing regular results with this class of iron have been close attention to chemical analysis and

regular testing for general hardness by the drill method. But it should be remembered that with these strong irons a much stiffer machine is required than that known as the Keep's machine. Owing to its lack of rigidity the author's experience with this machine has been disappointing.

Regularity of hardness, which is a governing factor of high physical properties, is only attainable by strict attention to blast pressure, and in this connection a recording blast pressure gauge attached to the cupola is most desirable.

A test becoming general in Europe for cast irons of the highest physical properties, more particularly in connection with casting for Diesel and large gas engine piston and cylinder liners, is the shock test. This is carried out by testing a bar cast 40 millimetres square supported on knife edges 160 millimetres apart by dropping on to it a weight of 12 kilograms from varying heights. Attached to the weight in such a way as to strike the bar in the centre parallel to the supporting knife edges is fixed another knife edge. The face of all the knife edges are rounded to a 1/16-inch radius. So far as the author is aware this test is not in use in America. A general arrangement of such a machine is shown in Fig. 7.

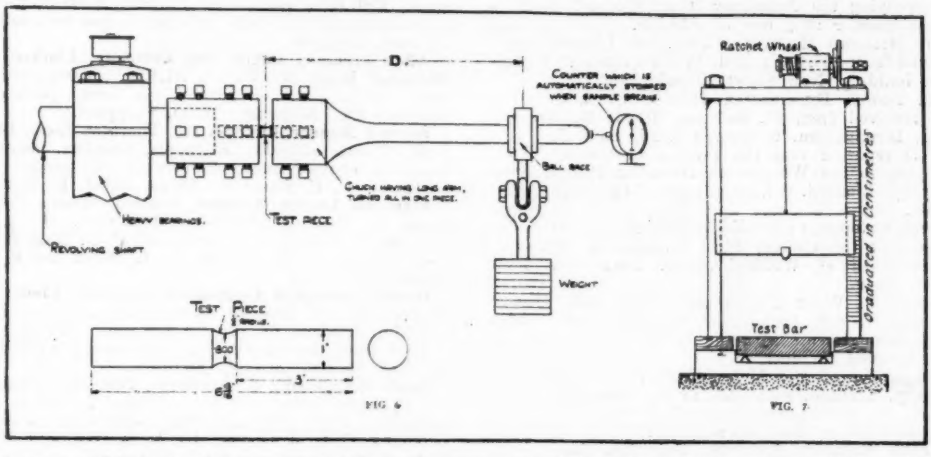


FIG. 6. FIG. 7.

In carrying out a shock test we commence with a drop of the weight from a height of 30 centimetres, increasing the height of the drop by increments of 5 centimetres until the sample breaks, the height at which the bar eventually breaks being taken as the test figure. A result of 55 centimetres is considered none too high for the class of work named, although it is quite a severe test. The maximum attained by the author has been 88 centimetres.

Mr. Wheeler uses the same sized bar and machine as a fatigue test, but for this commences with a drop of 28 centimetres and increases by heights of 1 centimetre. The number of blows required to fracture the sample should be taken as the fatigue-test numeral.

A bar from the same metal as the tensile bar of Mr. Wheeler's referred to in the early part of the paper withstood 30 blows, having a range from 28 to 57 centimetres.

In conclusion, as has been suggested in the first part of this paper, there is a wide difference in the strength of the respective grey cast-irons, of which some particulars in regard to the British have been given, the author would suggest the query whether this may not be due to the slow running furnaces in Great Britain producing metal having better properties than that made by the large fast running furnaces which appear to be general in America. Unfortunately, even in Great Britain the slow running furnaces are diminishing in number.

The author's best thanks are due to Professor Turner for help with some of the micrographs, and to Messrs. Bellis and Morcom for their permission to publish some of the results.

MR. CHARLES SOUTHERAN, one of the head officials of Dorman, Long & Company, Limited, Zetland Road, Middlesbrough, has been the recipient of a presentation on the occasion of his retirement after forty-two years' service

Display Facilities for British Travellers in New York.

His Majesty's Consul-General at New York (Mr. H. Gloster Armstrong) calls attention to the facilities which are now available to the representatives of United Kingdom firms visiting New York, at the offices of the British Empire Chamber of Commerce in that city. The Chamber, which has recently taken new premises in the Cunard Building, 25, Broadway—one of the largest and most modern structures in the city—has arranged for the formation of a sample room where British commercial travellers can, for a moderate charge, exhibit their goods, take orders, obtain office facilities and clerical assitance, and generally make it their headquarters during their stay in New York.

The Consul-General feels that this arrangement should prove extremely useful to the representatives of British firms, enabling them to display small samples in economical and advantageous circumstances. British travellers visiting the United States with samples have in the past been greatly hampered and delayed by the necessity of negotiating for a suitable room before circularising their customers.

It is suggested that firms requiring the use of the sample room for their representative should communicate with the Chamber well in advance, at the same time furnishing a list of their American customers, to whom the Chamber would then issue official invitations to meet the representative at a fixed date. Local firms known to the Chamber as interested in the trade concerned, though not listed as customers of the firm, would also be communicated with in the hope of securing their custom. It is understood that the Chamber would also render assistance, if desired, in the issuing of circulars or in the distribution of catalogues or literature, on basis of cost. The charge for rent will be $10 per day per room, inclusive of light and heat.

Contracts Open.

Exmouth, July 24.—Supply of about 45 tons of 6-in. cast-iron pipes and specials, for the Exmouth Urban District Council. Mr. S. Hutton, engineer and surveyor, Council Offices, Exmouth.

Maldon, Essex, July 25.—Supply of about 2,120 yards 4-in. cast-iron pipes, for the Maldon Rural District Council. Mr. W. Almond, engineer, 6, Market Hill, Maldon, Essex.

Warrington, July 24.—Supply of cast-iron circulating pipes, steam pipes, feed tank, etc., for the Electricity and Tramways Committee. Mr. F. V. L. Mathias, borough electrical and tramways engineer, Howley, Warrington. (Fee £1 1s., returnable.)

MR. N. KILVERT, J.P., chairman of Browett, Lindley & Company, Limited, of the Lancashire Dynamo and Motor Company, Limited, and of the Lancashire Ordnance Accessories Company, Limited, who died on March 24 last, aged sixty-three years, left estate of the gross value of £176,863, with net personalty £128,501.

Trade Talk.

MR. CHARLES ERITH, trading as Charles Erith and Company, has removed to Palace Chambers, Bridge Street, London, S.W.1.

MR. J. DENTITH, iron and steel merchant, has removed from 6, Stephenson Place, to Furness Chambers, Stephenson Place, Chesterfield.

TRUSLOVE & COMPANY, Colchester, have appointed Mr. J. Sambidge as their London manager at 17, Victoria Street, Westminster, S.W.1.

THE STAMPING & PRESS TOOL COMPANY, LIMITED, have removed from Oaklands Road, Cricklewood, to Station Works, Richmond, Surrey.

THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, are supplying the Aylesbury Town Council with a turbo-alternator at a cost of £10,302.

THE MIDLAND MACHINERY COMPANY, LIMITED, have removed from 108, Dale End, to the Chamber of Commerce building, New Street, Birmingham.

THE NORTH BIRMINGHAM IRON & STEEL COMPANY have removed from 28, Selborne Road, Handsworth Wood, Birmingham, to George Road, Solihull.

IT is reported that the furnace at Cleator Moor, belonging to the Whitehaven Hematite Iron & Steel Company, Limited, will be put out of operation immediately.

AFTER a stoppage extending over sixteen months, the furnaces of the United Steel Companies (formerly Messrs. Butlin's), Wellingborough, have now been lighted again.

GEORGE F. WEST & COMPANY, Iddesleigh House, Westminster, S.W.1, have terminated their sales agency arrangements with the Widnes Foundry Company, Limited, Widnes.

THE tender of the Metropolitan-Vickers Electrical Company, Limited, submitted to the Wellington City Council, for the supply of electrical material at their new power house, has been accepted.

ALFRED HERBERT, LIMITED, Coventry, have been appointed sole selling agents in Canada for the mining machinery, air compressors, rock drills and pneumatic tools made by Holman Bros., of Camborne, Cornwall.

THE imports of foreign iron ore at the Senhouse Dock at Maryport for the half year ending June 30 were 43,800 tons, compared with 8,200 tons for the previous six months, and 25,000 tons at the corresponding period of last year.

DORMAN & SMITH, LIMITED, have appointed Mr. H. J. D. Thompson to represent them on the N.E. Coast, and Mr. Thompson has opened an office at 28, Grainger Street, Newcastle-on-Tyne, where he will deal with inquiries for switchgear, fittings, etc.

A TRUST DEED dated June 14, 1922, to secure £1,500,000 first debenture stock, has been registered by the Consett Iron Company, Limited, in connection with the recent public issue of debentures. This constitutes the first entry on the company's "register of mortgages and charges" since its incorporation in 1864.

SOME recent foreign orders secured by Automatic & Electric Furnaces, Limited, include three from India, six from Norway, one from Australia, two from France, one from Spain, three from Holland, one each from Japan, Denmark and Buenos Aires, and two from Germany.

THE UNDERFEED STOKER COMPANY, LIMITED, have lately taken orders for travelling grates and ash conveyors from the St. Helens, Amsterdam, Dover, Penarth, Belfast, Sydney (N.S.W.), and Osaka Electric Light and Power Stations, and the Lewis Merthyr Collieries, Great Mountain Collieries, Coppee Company, Pentremawr Collieries, and James Nimmo & Company.

THE SPEARING BOILER COMPANY, LIMITED, have been successful in securing the contract for a complete boiler house equipment, consisting of three boilers, each of a normal evaporation of 50,000 lbs., together with Ferguson superheaters, economisers, mechanical stokers, induced draught plant, chimneys, steam, feed and other pipework, and ash handling plant, for the Stepney Borough Electricity Department.

MR. J. J. BURTON, of Middlesbrough, intimates that he has resigned his position as managing director of the Tees Furnace Company, Limited. Arrangements have been made by which the Roseberry and Ayton Banks Ironstone Mines, hitherto carried on by the Tees Furnace Company, Limited, will in future be carried on by Mr. Burton and his son, Mr. George A. Burton, under the name of Burton and Son.

OUT of a deficit of £1,040,173 in the accounts of the Ordnance Factories for the year ended March 31, 1921, £582,763 is for work done in the manufacture at Woolwich of 100 locomotives for which no definite purchasers had been obtained. The Controller says that further expenditure has been incurred since, and the locomotives have been reported to the Disposal and Liquidation Commission for sale, but he is not aware that any have yet been sold.

Company News.

Greenwood & Batley, Limited.—Final dividend, 3½ per cent., making 6 per cent.

B. H. Hirst, Limited.—Capital £400. General engineers, etc. Directors: B. H. Hirst and H. E. Frith.

Falkland Engineering Company, Limited, 140, Falkland Road, Harringay, N.—Capital, £2,000 in £1 shares. Directors: A. E. Hemingway and J. A. Brough.

Gloucester Railway Carriage & Wagon Company, Limited.—Dividend for half-year to May 31, 10 per cent. per annum, making 10 per cent. for year, less tax.

Rother Iron Works, Limited, the Fishmarket, Rye, Sussex.—Capital £10,000. Permanent directors: L. G. Walters, G. T. Jennings, G. Lomer, and E. H. Prior.

Vickers, Limited.—Profit, £708,103; brought forward, £991,639; preference dividend, £395,707; ordinary dividend, 5 per cent. per annum, less tax; carried forward, £872,993.

Albro Fillers & Engineering Company, Limited, 34, Holloway Road, N.—Capital £1,100 in 2,000 ordinary shares of 1s. each and 1,000 5 per cent. preference shares of £1. Secretary: M. O. Sheppard.

Binns & Mander, Limited, 179, Thornton Road, Bradford.—Capital £20,000. Engineers, founders, manufacturers of engines and machinery of all kinds, etc. Directors: D. H. Binns, W. Binns, and J. D. Mander.

Scammell Lorries, Limited, Fashion Street, Spitalfields, E.—Capital £250,000. Directors: J. Allan (chairman), Lt.-Col. A. G. Scammell, P. G. Hugh (technical director), A. I. Bellisha, H. L. Mond, and E. W. Rudd.

Horseley Bridge & Engineering Company, Limited.—Profits, £19,190; brought forward, £12,384; available, £31,574; dividend for year, 5 per cent., free of tax; reserve fund (increasing this account to £90,000), £10,000; carried forward, £9,074.

Essex Engineering & Machinery Company, Limited, 11, Tavistock Square, W.C.1.—Capital £3,000 in 120 preference shares of 1s. and 2,994 ordinary shares of £1. Directors: C. H. J. Gooch, Mrs. M. A. White, J. R. S. Hawker (secretary), and T. J. White.

Falkirk Iron Company, Limited.—Further dividend, 5 per cent. actual, less tax, making 10 per cent.; depreciation, £5,877; debenture trust reserve, £4,500; formation of company and debenture issue, £8,554; reserve for depreciation of investments, £5,560; carried forward, £40,678.

General Electric Company, Limited. — Net profit, £566,581; brought forward, £348,093; total, £914,675; debenture stock interest, £182,431; depreciation, £161,744; contribution to pension fund, £15,282; dividend on A preference, 6½ per cent. per annum, £110,876; dividend on B preference, 7½ per cent. per annum, 121,717; available balance, £322,622; ordinary dividend, 5 per cent. per annum, £105,598; carried forward, £217,024.

Gazette.

MESSRS. J. H. COLLIE and F. B. COX, consulting engineers and agents, 65, Fleet Street, Liverpool, trading as Collie & Cox, have dissolved partnership.

THE MELVIN ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. H. F. Inkson, Guildhall Annexe, 23, King Street, London, E.C.2, as liquidator.

THE partnership heretofore subsisting between Messrs. G. H. White, W. H. Brindley, and F. Osborne, engineers, Bailey Street, Sheffield, under the style of the St. Thomas General Engineers, has been dissolved.

MR. F. RIDGWAY and Mr. T. Tynan, 21, Bowling Old Lane, Bradford, trading under the style of Ridgway & Tynan, electrical engineers, are paying first and final dividends of 4s. 7d. and 10d. in the £. respectively in their separate estates.

RECEIVING orders have been made in connection with the affairs of Mr. R. Springer, 253, Plymouth Grove, Manchester, electrical engineer and contractor, and Mr. E. G. Rowe, 119, Dunraven Street, Tonypandy, Glamorgan, who traded as Davies & Rowe, electrical engineers.

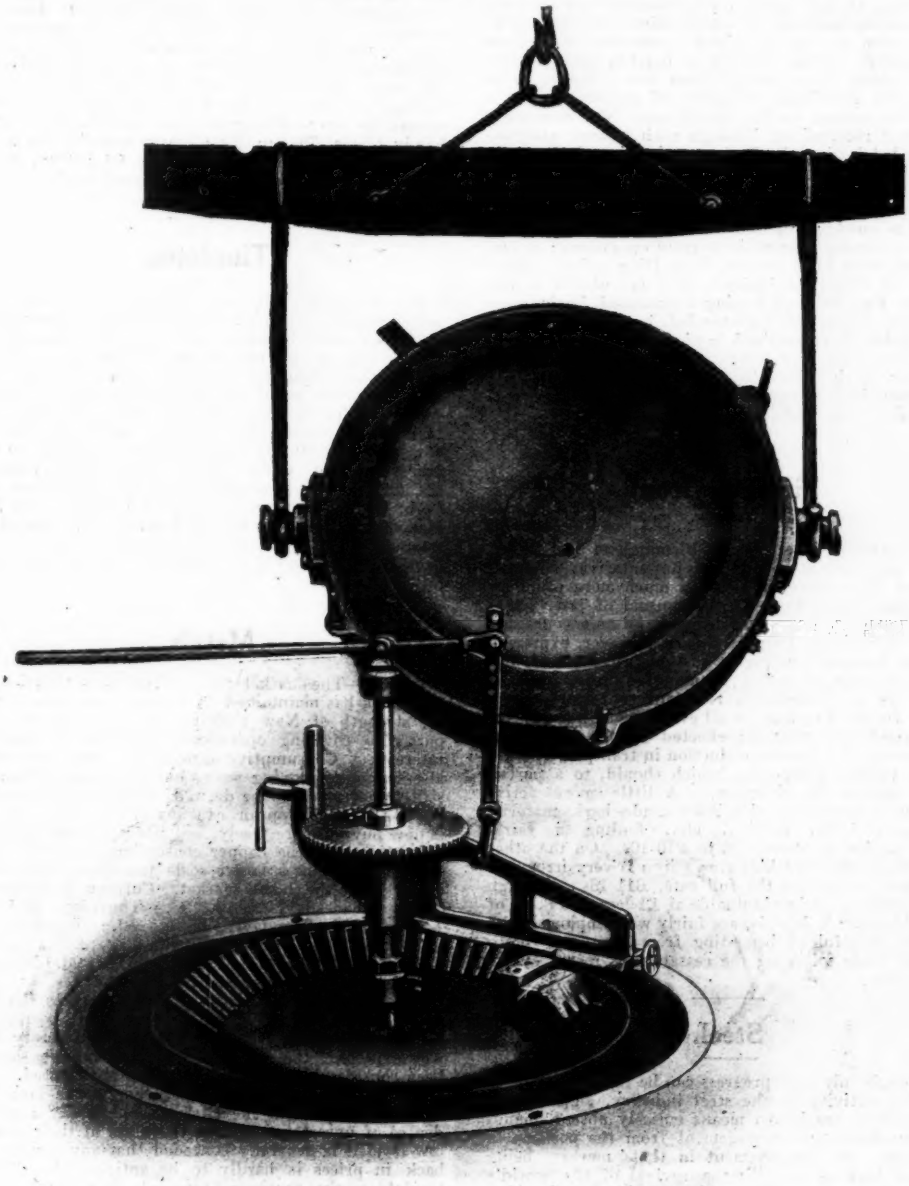
MESSRS. A. G. CLOWES and G. Anderson, iron and steel merchants, trading under the style of Clowes & Anderson, at Pheasant Grounds, Carbrook, Sheffield, have dissolved partnership. Mr. A. G. Clowes will continue the business under the style A. G. Clowes & Company.

THE LATE Mr. George Hill, of Victoria Cottage, Station Road, Shotts, Lanark, and of the Calderhead Foundry, Shotts, left £11,887.

SINCE the first appeal was issued in May, 1920, a total of nearly £7,400 has been subscribed towards the War Memorial of the Imperial College of Science and Technology. A memorial tablet has been erected and unveiled in each of the three constituent colleges, and the remainder of the money has been used in part purchase of a sports field.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,

(MANCHESTER), LIMITED,

BLACKFRIARS, MANCHESTER.

IRON AND STEEL MARKETS.

Pig-iron.

The general position of the pig-iron trade during the past week, though practically unchanged in essentials, has certainly marked one outstanding development in the decision of the Cleveland ironmasters to restore the freedom of the markets as regards price adjustments, which, as in pre-war times, are in future to be left to the individual judgment of makers, and is a return to normal trading conditions. The announcement was received on 'Change with general satisfaction as betokening the final emancipation of the trade from the restrictions, both official and self-imposed by which the trade in pig-iron has so long been shackled. The termination of the Cleveland fixed price agreement has quickly followed the attempt of the Scottish makers to revive interest in warrant operations; so far, however, with little success, Iron Ring sellers' offers failing to stimulate business of a speculative order. Glasgow Fair holidays having commenced, business on Clydeside is practically suspended, but a hopeful view of the future is entertained in pig-iron circles, although as yet there have been few movements to justify general optimism in that direction. Offers of Continental pig are reported at favourable cut prices, but, so far, Scottish makers are holding for firm quotations.

Finished Iron.

The quarterly meeting at Birmingham last week, which was well attended by representatives from all parts of the country, disclosed a much more confident and hopeful tone than has been usual of late, based on an expansion of general demand and an encouraging volume of inquiry. Complaints are, however, expressed that the business offering at current prices affords but a bare margin of profit to manufacturers, some of whom are in consequence reluctant to restart operations. In one direction, at all events, some remedy for these conditions may be effected by the recent announcement of a further reduction in transport charges by the railway companies, which should, to a partial extent relieve the situation. A little more active demand is noted for the lower-grade bars, material for nuts, bolts, fencing, etc., finding a fairly steady market at about £10 to £10 10s. On the other hand, South Staffordshire crown iron is very irregular, some makers quoting the full rate, £11 15s., although a fair quality can be obtainable at £1 less. Makers of marked bars, S.S brands, are fairly well employed, and are also hopeful of benefiting from improved conditions of trade following the cessation of recent labour difficulties.

Steel.

Although only slow progress can be reported towards returning activity in the steel industry, signs of an early revival are by no means entirely absent, manufacturers deriving encouragement from the position in the States, any improvement in that market being accepted here as signalling a revival of the world's demand for material. That this assumption is justified is to a certain extent confirmed by a steady increase in orders and inquiries on American account, last month's shipments to Atlantic ports having been heavier than for the past twelve months. With regard to the armament departments, there is still some work on hand for both the United States and home Governments, while the recent decision to place contracts for two capital ships for the Navy in hand will go far to relieve unemployment in the heavy steel branches. Demand for steel for engineering and constructional purposes is slow in materialising, the branch most favoured so far having been the production of textile machinery, for which orders in hand include important contracts both on home and overseas account, though business is in many cases still retarded by buyers' anticipations of lower prices in the near future. Export trade in agricultural machinery continues restricted in volume, makers now depending largely upon home demands, to which much more attention is directed by makers to compensate for the depressed condition of overseas' markets. At present production of semi-products is improving, soft billets especially being in fairly active demand, while makers of cold rolled strip are also well employed. Market movements, however, indicate little variation of current steel prices, which remain, on the whole, unchanged from last week's quotations.

Scrap.

Conditions in the markets for scrap metals continue unsettled, the only exception to general stagnation being a limited amount of buying at Sheffield, where there is a revival of demand for steel material for remelting purposes. On the North-East Coast the business passing in scrap is spasmodic, and does not amount to a great deal. There are a few openings for sheet scrap, but the works price of 60s. per ton is met by sellers' offers round about 62s. 6d. to 65s. delivered. Moderate parcels of steel turnings and cast-iron borings are changing hands at 45s. per ton. Other quotations are:—Heavy cast-iron machinery scrap in handy pieces, 79s. to 80s.; heavy wrought-iron scrap, bushelling and piling, nominal, 62s. 6d.; ditto, special heavy forge, 70s. to 75s. All delivered works.

Tinplates.

The market for tinplates continues steady, but business generally is quiet. Makers seem to have fairly well filled order books for 4-6 weeks ahead, and they are showing no anxiety to press sales for delivery beyond this. Spot lots are still wanted, and are commanding round about 19s. 9d to 20s. Basis. Current quotations for the standard sizes rule:—Coke tins, IC 14 x 20, 112 sheets, 108 lbs., 19s. 6d. to 19s. 9d. per box; IC, 28 x 20, 112 sheets, 216 lbs., 39s. 3d. to 40s. per box, net cash, f.o.b. Wales. Terneplates.—18s. 6d. basis is generally quoted for usual lines, net, f.o.b. Wales, but there is not much business to be had. Makers are booked up to end August. The market for wasters is not too brisk at the moment. A moderate home trade demand is reported, but export orders have fallen off.

Metals.

Copper.—The market for standard copper during the past week has maintained its firmness, consequent upon the strength of New York prices for electrolytic, and partly to covering operations traceable to American interests. Consumptive demand on home account is also on an improving scale, but Continental business still leaves much to be desired owing to the disturbed conditions of European exchanges. France, however, is now buying more freely, and advices from the States indicating that the copper consuming industries there are operating on a larger scale justifies an optimistic outlook for the home market. Current quotations.—*Cash*: Wednesday, £63 3s. 9d.; Thursday, £63 5s.; Friday, £63; Monday, £63 1s. 3d.; Tuesday, £63 2s. 6d. *Three Months*: Wednesday, £63 11s. 3d.; Thursday, £63 13s. 9d.; Friday, £63 8s. 9d.; Monday, £63 8s. 9d.; Tuesday, £63 8s. 9d.

Tin.—In this section of the metal markets the tone continues consistently firm, the statistical position of standard tin being regarded as more satisfactory than was expected, the increase in visible supplies having been considerably less than had been anticipated. Consideration must, however, be given to the large unliquidated stocks in the East, which justify a certain degree of uncertainty, but with values at their present low level it is generally conceded that any serious setback in prices is hardly to be anticipated. Welsh tinplate works continue to absorb fair quantities of metal, but Continental inquiry is restricted and America is not displaying much interest. Much will depend on how things turn out in Europe and in America, since in both cases there are troubles of one sort or another which tend to make consumers cautious. Current quotations.—*Cash*: Wednesday, £153 7s. 6d.; Thursday, £153 2s. 6d.; Friday, £153 5s.; Monday, £153 12s. 6d.; Tuesday, £155 2s. 6d. *Three Months*: Wednesday, £154 3s. 9d.; Thursday, £153 15s.; Friday, £153 17s. 6d.; Monday, £154 7s. 6d.; Tuesday, £155 12s. 6d.

Spelter.—The market for this metal continues firm, with values again on the up-grade. Production is still restricted until accumulated stocks are reduced in bulk, but should some increase in demand materialise the position would speedily develop an improvement. Current quotations.—*Ordinary*: Wednesday, £28 5s.; Thursday, £28 10s.; Friday, £28 17s. 6d.; Monday, £29; Tuesday, £29 5s

Lead.—Supplies of soft foreign pig are still limited in bulk, but with demand restricted values are a shade easier. The Continental demand shows a slight improvement, but home consumers are holding off the market. English lead is firm. Current quotations.—*Soft foreign (prompt)*: Wednesday, £25 2s. 6d.; Thursday, £25; Friday, £25 5s.; Monday, £25 10s.; Tuesday, £25 5s.

Telephone: 21, Penistone. Telegrams: "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

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TWO NEW Labour Savers FOR THE FOUNDRY

1. FOUNDRY FLOOR DRESSER.
Turns over and mixes the sand, operated by crane man and one labourer.

2. NEW LOAM CORE-MAKING MACHINE.
Straight cores on barrels run up by one man in less time, and truer cores produced.

On View at Foundry Exhibition, Birmingham, June, 1922.

PATENTS APPLIED FOR.

MAKERS

RITCHIE, HART & Co., Ltd.,

Engineers **BELFAST.**

WEEKLY PRICE CURRENT.

COPPER.

	£	s	d.
Standard cash	63	2	6
Three months	63	8	9
Electrolytic	70	10	0
Tough	66	5	0
Best selected	66	5	0
Sheets	94	0	0
India	83	10	0
Wire bars	71	17	6
Do. Aug.	71	17	6
Do. Sept.	—		
Ingot bars	71	17	6
H.C. wire rods	76	10	0
Off. aver. cash, June	62	0	11 1/4
Do. 3 mths., June	62	8	5 1/4
Do. Settlement June	62	1	0
Do. Electro, June	70	1	2
Do. B.S., June	67	12	2
Aver. spot price, copper, June	61	19	11 1/2
Do. Electro, June	70	15	8 1/2
Solid drawn tubes			13 1/2d.
Brazed tubes			13d.
Wire			10 1/2d.
Yellow metal rods			6 1/2d.
Do. 4x4 Squares			8 1/2d.
Do. 4x3 Sheets			9 1/2d.

BRASS.

Solid drawn tubes	11 1/2d.
Brazed tubes	13d.
Rods, drawn	10 1/2d.
Rods, extruded or rolled	6 1/2d.
Sheets to 10 w.g.	9 1/2d.
Wire	9 1/2d.
Rolled metal	9 1/2d.

TIN.

	£	s	d.
Standard cash	155	2	6
Three Months	155	12	6
English	155	0	0
Bars	157	0	0
Chinese	153	2	6
Straits	156	10	0
Australian	157	0	0
Eastern	156	15	0
Banca	155	2	6
Off. aver., cash, June	152	12	3 1/2
Do. 3 mths., June	153	14	5 1/2
Do. Sttlment June	152	12	3 1/2
Aver. spot, June	152	11	1

SPELTER.

	£	s	d.
Ordinary	29	5	0
Remelted	26	0	0
Hard	20	10	0
Electro 99.9	33	5	0
English	29	7	6
India	22	10	0
Prime Western	29	5	0
Zinc dust	40	0	0
Zinc ashes	4	15	0
Off. aver., June	27	16	1 3/4
Aver., spot, June	27	17	11 1/2

LEAD.

	£	s	d.
Soft foreign ppt	25	5	0
English	26	5	0
Off. average, June	24	3	2 1/4
Average spot, June	24	14	2

ZINC SHEETS.

	£	s	d.
Zinc sheets, English	36	0	0
Do. V.M. ex. whf.	36	0	0
Dutch	36	0	0
Rods	41	0	0
Boiler plates	34	0	0
Battery plates	34	10	0

ANTIMONY.

	£	s	d.
English regulus	25	15	0
Special brands	32	10	0
Chinese	24	10	0
Crude	14	10	0

QUICKSILVER.

Quicksilver 11 10 0 to 12 10 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s	d.
Ferro-silicon—			
45/50%	13	2	6
75%	23	0	0
Ferro-vanadium— 35/40%	18/3 lb. va.		
Ferro-molybdenum— 70/75%	6/6 lb. mo.		
Ferro-titanium— 23/25%, carbonless	1/2 lb.		
Ferro-phosphorus, 20/23%,	£20		
Ferro-tungsten— 80/85%, carbon free	1/5 lb.		
Tungsten metal powder— 98/99%	1/8 lb.		
Ferro-chrome— 4/6% car.	£24		
6/8% car.	£23	10	
8/10% car.	£23	5	
Ferro-chrome— Max. 2% car.	£68		
Max. 1% car.	£78		
Max. 0.70% car.	£94		
67/70%, carbonless	1/9 1/2 lb.		
Nickel—99%, cubes or pellets	£160		
Cobalt metal—98/99%	10/6 lb.		
Aluminium—98/99%	£100		
Metallic Chromium— 96/98%	5/- lb		
Ferro-manganese (net)— 76/80%, loose	£15		
76/80%, packed	£16		
76/80%, export	£14	10	
Metallic manganese— 94/96%, carbonless	2/4 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	2	6
Finished bars, 18% tungsten	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. to 8 in. inclusive 4d. lb.

Rounds and squares under 1/4 in. to 1/2 in. 3d. lb.

Flats under 1 in. by 1/4 in. to 1/4 in. by 1/2 in., and all sizes over four times in width over thickness 3d. lb.

Bevels of approved sizes and sections 6d. lb.

If in coils 3d. lb.

Packing £3 ton.

Bars cut to length 10% extra

Scrap from high-speed tool steel—

Scrap pieces 3d.

Turnings and swarf 1d

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy Steel	3	10	0	3	15	0
Bundled steel & shearings	2	18	0	3	10	0
Mixed iron & steel	2	17	6	3	7	6
Heavy cast iron	3	10	0	4	0	0
Good machinery for foundries	4	0	0			
Cleveland—						
Heavy steel	3	0	0			
Steel turnings	2	5	0			
Cast-iron borings	2	5	0			
Heavy forge	3	10	0			
Bushelled scrap	3	2	6			
Cast-iron scrap	3	19	0			
Lancashire—						
Cast iron scrap	4	2	6			
Heavy wrought	3	5	0			
Steel turnings	2	2	6			

London—	£	s.	d.
Copper (clean)	54	10	0
Brass (clean)	29	0	0
Lead (less usual draft)	20	10	0
Tea lead	18	10	0
Zinc	16	0	0
New aluminium cuttings	65	0	0
Braziery copper	44	10	0
Gun metal	39	0	0
Hollow pewter	120	0	0
Shaped black pewter	70	0	0

Above are merchant's buying prices delivered yard.

PIG-IRON.

N. E. Coast—	
Foundry No. 1	95/-
Foundry No. 3	90/-
Forge No. 4	85/-
Mottled	80/-
Hematite No. 1	95/-
Hematite M/Nos.	94/-
Midlands—	
Staffs. common	—
„ part-mine forge	—
„ „ foundry	—
„ Cold blast	240/-
„ basic	—
Northants forge	70/- to 72/6
„foundry No. 3	77/6 „ 80/-
„ basic	82/6
Derbyshire forge	75/-
„ foundry No. 3	82/6
„ basic	80/-
Scotland—	
Foundry No. 1	100/-
„ No. 3	95/-
Hematite M/Nos.	110/-
Sheffield (d/d district)—	
Derby forge	82/6
„ foundry No. 3	86/6
„ basic	—
Lincs. forge	86/6
„ foundry No. 3	86/6
„ basic	86/6
E.C. hematite	107/6
W.C. hematite	115/-
All d/d in the district.	
Lancashire (d/d eq. Man.)	—
Derby forge	—
„ foundry No. 3	92/6
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
„ foundry No. 3	—
Summerlee foundry	112/-
Glengarnock foundry	114/6
Gartsherrie foundry	114/6
Monkland foundry	112/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (crown)	£10 10 to £12		
Angles	£11 to £12	10	0
Tees to 3 united ins.	£11 10 to 13	0	0
Nut and bolt	10	0	0
Hoops	14	0	0
Marked bars (Staffs.)	13	10	0
Gas strip	11	7	6
Bolts and nuts, 1/4 in. × 4 in.	20	10	0
Steel—			
Ship plates	10	0	0
Boiler plates	13	10	0
Chequer plates	10	10	0
Angles	9	10	0
Tees	10	10	0
Channels	8	15	0
Joists	10	0	0
Rounds & squares 3-in. to 5 1/2 in.	10	10	0
Rounds, under 3in. to 1/2 in.	9	10	0
Flats, over 5in. wide and up	10	0	0
Flats 5in. to 1 1/2 in.	8	10	0
Rails, heavy	9	10	0
Fishplates	14	10	0
Hoops	12	0	0
Black sheets, 24 g.	12	0	0
Galv. cor. sheets, 24 g.	15	15	0
Galv. fencing wire, 8 g. plain	16	0	0
Rivets, 1/2 in. dia	14	0	0
Billets, soft	7 5 0 to 7	10	0
Billets, hard	8	0	0
Sheet bars	7 7 6 to 7	10	0

PHOSPHOR BRONZE.

	Per lb basis.
Strip	1 3
Sheet	1 3 1/2
Wire	1 3 1/2
Rods	1 2 1/2
Tubes	1 6
Castings	1 1

Delivery 3 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

CHARLES CLIFFORD & SON LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	11d. to 1/5
Rolled—	
To 9 in. wide	1/5 to 1/11
To 12 in. wide	1/5 1/2 to 1/11 1/2
To 15 in. wide	1/6 1/2 to 2/0 1/2
To 18 in. wide	1/7 1/2 to 2/1 1/2
To 21 in. wide	1/8 1/2 to 2/2 1/2
To 25 in. wide	1/9 1/2 to 2/3 1/2
Ingots for spoons and forks	11d. to 1/5
Ingots rolled to spoon size	1/2 to 1/8
Wire round—	
3/0 to 10. G.	1/8 1/2 to 2/3 1/2

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	27.64
No. 2 foundry Valley	24.00
No. 2 foundry, Birm.	18.50
Basic	26.96
Bessemer	26.77
Malleable	26.46
Grey forge	25.27
Ferro-manganese 80 % delivered	70.82
Bess. rails, h'y, at mill	40.00
O.-h. rails, h'y, at mill	40.00
Bess. billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	40.00
	Cents.
Iron bars, Phila.	1.92
Steel bars	1.70
Tank plates	1.70
Beams, etc.	1.70
Skelp, grooved steel	1.70
Skelp, sheared steel	1.70
Steel hoops	2.50
Sheets, black, No. 28	3.15
Sheets, galv., No. 28	4.15
Sheets, blue an'l'd, 9&10	2.40
Wire nails	2.40
Plain wire	2.25
Barbed wire, galv.	3.05
Tinplate, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	32/6
„ furnace	22/6
Durham & North. foundry	28/-
„ furnace	23/6
Other Districts, foundry	27/6
„ furnace	22/6

SWEDISH IRON.

Bars, hammered basis sizes	Basis price £22 to £23
Rolled Ordinary—Assortment	£17 0 0 to £17 10 0
Nail Rods—Square, round and flats	£17 0 0 to £17 10 0
Keg Steel	nom. £38 to £40
Faggot Steel	nom. £30 to £32
Blooms—Single welded	£10 to £11
Billets—Single and double welded	£13 to £14
Pig-Iron—Grey, white or mottled	£8 to £8 15 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

Up to and incl. 6 in.

Gas	55%	Tube prices are now free.
Water	50%	
Steam	45%	

TINPLATES.

I.C.Cokes,	20×14, box	19/9
,,	28×20, ,,	39/6
,,	20×10, ,,	28/3
,,	18¾×14, ,,	20/-
I.X.	,	45/-
I.X.X.	,,	51/-
F.C.B.Y.	21×13⅝ ,,	37/6
C.V.B.G.	16½×15, ,,	34/9
I.C.W.	20×14, ,,	17/9
,,	28×20, ,,	36/-
,,	20×10, ,,	24/9
,,	18¾×14, ,,	18/3
Terneplates,	28×20, ,,	37/-

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
July 12	63	3	9	inc.	5/-
,, 13	63	5	0	,,	1/3
,, 14	63	0	0	dec.	5/-
,, 17	63	1	3	inc.	1/3
,, 18	63	2	6	inc.	1/3

Electrolytic Copper.

July 12	70	5	0	No change	
,, 13	70	5	0	,,	
,, 14	70	5	0	,,	
,, 17	70	10	0	inc.	5/-
,, 18	70	10	0	No change	

Standard Tin (cash).

July 12	153	7	6	dec.	2/6
,, 13	153	2	6	,,	5/-
,, 14	153	5	0	inc.	2/6
,, 17	153	12	6	,,	7/6
,, 18	155	2	6	,,	30/-

Tin (English ingots)

July 12	153	10	0	No change	
July 13	153	0	0	dec.	10/-
,, 14	153	5	0	inc.	5/-
,, 17	153	15	0	,,	10/-
,, 18	155	0	0	,,	25/-

Zinc Sheets (English).

July 12	36	0	0	No change	
,, 13	36	0	0	,,	
,, 14	36	0	0	,,	
,, 17	36	0	0	,,	
,, 18	36	0	0	,,	

Spelter (ordinary).

July 12	28	5	0	dec.	2/6
,, 13	28	10	0	inc.	5/-
,, 14	28	17	6	,,	7/6
,, 17	29	0	0	,,	2/6
,, 18	29	5	0	,,	5/-

Lead (English).

July 12	25	15	0	No change	
,, 13	26	0	0	inc.	5/-
,, 14	26	0	0	No change	
,, 17	26	5	0	inc.	5/-
,, 18	26	5	0	No change	

WM OLSEN LIMITED,

Cogan Street and 1-3-5-7 Spruce Street, HULL,

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Price Lists on Application.

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London: 10, Bush Lane, Cannon St., E.C.4.

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Telephons:— 11 Wellington, Salop. 5959 Central.

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in IRON, STEEL, COPPER and BRONZE.

Galvanised Telegraph, Telephone, Cable and Trolley Wire

To all Specifications.

Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.

BEST H. C. COPPER & BRONZE WIRE a speciality.

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PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

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COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

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ADVERTISER, Age 39, seeks position as Non-ferrous FOUNDRY MANAGER. Twenty-five years' practical experience. Thorough knowledge of up-to-date plant and practice. Unimpeachable references. Address, in first instance, Box 212, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY MANAGER or FOREMAN (38), disengaged, wants post; technical training; 23 years' experience grey iron and non-ferrous metals; general engineering and high-class light castings; greensand, drysand, loam, plate and machine; piece rate fixing; efficient cupola practice; good organiser; good references.—Box 216, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

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PARTNERSHIP: Good opportunity for energetic man, with small capital, as junior partner in old-established patternmaking business.—Apply, Box 222, Office of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

METALLURGIST AND FOUNDRY MANAGER (28), who has just relinquished control of a Foundry, desires permanent, progressive post. Green, dry and loam moulding, electric, Siemens, Bessemer and crucible melting; University metallurgical degree course, M.I.M. and M.I.S.I.—Box 224, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PATENTS.

THE PROPRIETOR OF THE PATENT No. 22,792 of 1910, for "Method of bessemerizing copper matte" is desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country.—All communications should be addressed in the first instance to HASELTINE, LAKE & Co., Chartered Patent Agents, 28 Southampton Buildings, Chancery Lane, London, W.C.2.

ENDLESS STEEL BELTS.—The Owner of British Patent No. 147667, which relates to the manufacture of Endless Steel Belts by Rolling from Seamless Tubing, is desirous of entering into negotiations for the granting of licences thereunder on reasonable terms.—Communications please address to DICKER & POLLAK, 20-23, Holborn, London, E.C.1.

MACHINERY.

FOR SALE.

Three Lancashire Boilers, 30 ft. x 7 ft. 6 in., now insured at 150 lbs. pressure. Two Cornish Boilers, 28 ft. x 6 ft. diameter, reinsure 90 lbs. pressure. Two Marine Boilers, 10 ft. 4 in. x 12 ft. 2 in. diameter, reinsure 150 lbs. pressure. One Vertical Cross Tube Boiler, about 12 ft. high x 6 ft. diameter, reinsureable 90 lbs. working pressure. One Vertical Boiler, 6 ft. 6 in. x 3 ft. 9 in. diameter, reinsure 80 lbs. pressure. Eight good Second-hand Single-ended, Three-furnace Marine Boilers, 10 ft. 2 in. long x 16 ft. 3 in. diameter, Foxe's Patent Furnaces, reinsureable at 145 lbs. per sq. in. working pressure. "Galloway" Boiler, 24 ft. x 6 ft. 8 in. diameter, reinsure 100 lbs. pressure.

Catalogue of Stock Machinery, 5-6,000 Lots Free on Application. Inspection Invited.

THOS. W. WARD, LTD.,
ALBION WORKS,
SHEFFIELD.

MACHINERY (*continued*).

MACHINERY FOR SALE.

4 FT. brand new Foundry Sand Mixer, two Steel Tubes, 6 ft. x 3 ft. diameter, make excellent Cupola. Sirocco 8-in. Belt Driven Fan, 7½-h.p. Campbell Oil Engine, small Planing Machine by Kershaw, 30-h.p. Hornsby Gas Engine, practically new. Low prices.

HARRY H. GARDAM & COMPANY, LIMITED, STAINES.

FOR SALE—SPECIAL.

Eight very good second-hand Single-ended, Four-furnace MARINE BOILERS, 10 ft. 2 in. diam. by 16 ft. 3 in. long, with all steam and furnace fittings, re-insureable at a working pressure of 145 lbs. per sq. inch. For details, price and copy of Insurance Co.'s report, apply—

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ALBION WORKS,
SHEFFIELD.

ONE new 2-ton Geared Ladle for sale; price £20.—For further particulars apply to TURNER, ATHERTON & COMPANY, LIMITED, Denton.

"BREAKIR" Improved Foundry Sand Disintegrators and Mixers (capacities from one to ten tons per hour), obtain many improvements. Write for leaflets and quotations to the makers, W. BREALEY & COMPANY, LIMITED, Russell Street, Sheffield, or their Agents.

MISCELLANEOUS.

NORTHAMPTON IRON ORE.—For sale, by order of Mortgagees, Farm containing 238 acres, valuable bed of Ironstone believed to exist thereunder, land adjoining worked. Above Farm key position to railway and adjoining land. Price freehold (cheap), £12,000.—Apply to MESSRS. MERRY & SON, Auctioneers, Northampton.

GROUND GANISTER, Fire Clay, Clean Sharp Sand for Furnace Bottoms, Astbury Silica Company (Established 30 years).—Write, D. BOULTON, Kidsgrove, Stoke-on-Trent.

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MOULDING Machines, 3 Darling and Sellars' turnover machines, 4 Tarbor pneumatic squeezers, 2 Evans duplex power squeezers, 2 Evans hand squeevers.

MOULDING Boxes, A large selection IN STOCK, send for list.

SAND Plant, New rotary Sifters £18 each, New mixers 48 in. casing £30 each, Two 4 ft. sandmills secondhand £22 each, One 6 ft. sandmill secondhand £60.

FOUNDRY Tools, Weights, shanks, clamps, crucible stands, rumblers, fans and blowers. ALL KINDS of foundry plant IN STOCK HERE.

ALEX. HAMMOND,
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"BOXTED"—SLOUGH—BUCKS.

Ground Ganister
FOR EVERY TYPE OF FURNACE.

Steel Moulders' Composition.
SUITABLE FOR ALL WEIGHTS AND DESCRIPTIONS OF STEEL CASTINGS.

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